

## **R7567 (Banana IPM Project) - PROTOCOL AK1**

|                             |   |
|-----------------------------|---|
| <b>TITLE:</b>               | The effect of enhanced plant nutrition as a management option of banana leaf spot diseases for highland bananas |
| <b>Lead Scientists:</b>     | W.Tushemereirwe   |
| <b>Activity Leader(s):</b>  | Kangire, A., Balekye, A., Ngambeki, D.  |
| <b>Project Funding:</b>     | DFID Crop Protection Programme  |
| <b>Research partners:</b>   | CABI UK and Natural Resources Institute, Univ. of Reading   |
| <b>Start and end dates:</b> | 2000 – 2003   |

### **Background:**

The rationale of the study stems from the previous studies, which indicated that good nutrition speeded up growth whereas the damage caused by the disease remained the same and thus counteract the impact of the disease. This study aims at establishing if the enhancing the nutrition makes economic sense.

### **Objectives:**

1. To determine the effect of enhanced plant nutrition on leaf spot management (to be re-stated)
2. To establish the associated costs and benefits involved

### **Materials and Methods:**

- (i) Location: Bamunanika sub-county in the Luwero district.
- (ii) Choice of farmers and sites: See Luwero Benchmark site report for the period July 2000 – May 2001 for details concerning stakeholder participation, choice of farmers and choice of sites.
- (iii) Farmers participating in trial: 20 farmers (see Table 1a for a listing) from 6 parishes. However, 4 farmers subsequently dropped out of the trial: one because his/her plants were eaten by animals; one could not get mulch; two neglected their plants which subsequently died.
- (iv) Planting date: October 2000
- (v) Cultivars: East African highland bananas, namely, Mpologoma, Nakitembe, Atwalira, Nfuka and Mbwarzirume. These cultivars had been multiplied as tissue culture material and were made available to the participating farmers in Luwero.
- (vi) Trial layout: 2 x 2 factorial on four main plots in each farm. Five subplots having the 5 cultivars allocated randomly. The 2 factors were (a) Manure with mulch applied or not; and (b) Whether or not fungicide was applied using triadimenol (Bayfidan EC 250) at a rate of 0.625 ai per litre of water applied on soil at the base of each plant. In each sub-plot, there were 5 mats, spaced 3 metres apart. Where applied, nutrition used by the farmer comprised organic materials (like cow dung, compost manure) at least once a year (20 – 25 kg manure per mat)).



- So 25 mats per main plot. An example of a typical layout is presented below. Each row represents 10 plants of one single cultivar. Two randomisations done: one for the first 5 rows in diagram below and a second randomisation for the next 5 rows.

|   |                                 |   |   |   |   |   |                                    |   |   |  |
|---|---------------------------------|---|---|---|---|---|------------------------------------|---|---|--|
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | mulch + manure;<br>fungicide    |   |   |   | X | X | mulch + manure;<br>no fungicide    |   |   |  |
| X |                                 |   |   |   | X | X |                                    |   | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | no mulch + manure;<br>fungicide |   |   |   | X | X | no mulch + manure;<br>no fungicide |   |   |  |
| X |                                 |   |   |   | X | X |                                    |   | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |
| X | X                               | X | X | X | X | X | X                                  | X | X |  |

- (vii) Trial management/Inputs: Management was by farmers. One field assistant (FA), by the name of Mugerwa, on-site in Luwero, was visiting each farmer at least once in two weeks (5 farmers per day). Information on labour, inputs, and sucker distribution collected by farmers and transcribed by Mugerwa into data sheets.
- (viii) Data collection process: Information on labour inputs are recorded by the farmers. The technicians record information on pests, diseases and growth parameters. Data recorded by the farmer and later copied by the FA onto his own recording sheets. These are then brought back to Dezi once in two weeks. (Note: there are two sets of recording sheets for the farmer: when one set comes back, the other set gets taken back to the field). Technician also collects information on sigatoka, i.e. the number of the youngest leaf affected.

Three technical assistants collect information on nematodes and weevils.

#### **Data collected:**

##### **Biological data by cultivar type**

- Planting – shooting period
- Plant growth parameters (Girth, Height, Total leaves,)
- Snapping
- Plant tissue and soil nutrient analysis
- Flowering date, number of leaves , the youngest leaf spotted
- Yield: Bunch weights, number of hands, number of leaves
- Disease and pest monitoring (weevils , BSV , fusarium wilt )

##### **Socio Economic data**

- Farmer category, sex, age, education , land size , land under bananas
- Farm labour – source of labour (family , hired ) , labour inputs / farm activity / age / gender / days / hours per day worked
- Farm activities – land clearing, ploughing, hole preparation, planting, weeding, manure composting carrying and application, mulching ,making trenches , pruning , intercropping , desuckering , general sanitation , harvesting and transport
- Inputs type (e.g. cow dung, compost manure, mulch, coffee husks) , source of input , cost of input , methods of application and rate of application

##### **Sucker distribution**

- Date, cultivar type, number of suckers given free, number of suckers sold and cost, name of beneficiary, village, parish and sub county of the beneficiaries.

**Protocol filename:** L\_EN\_Protocol\_AK1.doc



**Table 1a - List of farmers participating in the Nutrition Trial**

| Name                      | G   | W   | N   | Socio-economic data |        |       |       |        | Parish    | Village         | Planting date |
|---------------------------|-----|-----|-----|---------------------|--------|-------|-------|--------|-----------|-----------------|---------------|
|                           |     |     |     | Suckers             | Inputs | Crops | Hired | Family |           |                 |               |
| 31. Mr. Pascal Mpoza      | Yes | No  | No  | No                  | No     | No    | No    | No     | Kyampisi  | Luteete         | 10/10/2000    |
| 32. Mr. Haluna Yiga       | No  | No  | No  | No                  | Yes    | Yes   | Yes   | Yes    | Kibanyi   | Kalwe           | 11/10/2000    |
| 33. Mr. Umara Lubega      | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibanyi   | Kibanyi         | 11/10/2000    |
| 34. Mr. Derrick Lukwago   | Yes | No  | No  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibanyi   | Kibanyi         | 11/10/2000    |
| 35. Ms. Anne Nakiwala     | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiteme    | Kiteme          | 12/10/2000    |
| 36. Mr. Kikonyogo Salonga | No  | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kyampisi  | Magogo          | 13/10/2000    |
| 37. Mr. Joseph Kaggwa     | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Kakira          | 13/10/2000    |
| 38. Mr. Edward Wamala     | No  | No  | No  | No                  | Yes    | Yes   | Yes   | Yes    | Mpologoma | Kangulumira     | 13/10/2000    |
| 39. Mr. James Serubiri    | No  | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Mityebiri       | 14/10/2000    |
| 40. Mr. Yusuf Mukasa      | No  | Yes | Yes | No                  | Yes    | Yes   | Yes   | Yes    | Mpologoma | Buto            | 14/10/2000    |
| 41. Mr. Senabulya         | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Mityebiri       | 14/10/2000    |
| 42. Mr. Alosius Mugenzi   | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibanyi   | Bugabo          | 16/10/2000    |
| 43. Mr. Kakooza           | No  | No  | No  | No                  | No     | No    | No    | No     | Sekamuli  | Kito            | 16/10/2000    |
| 44. Mr. Mukumbya          | Yes | Yes | Yes | Yes                 | Yes    | Yes   | No    | Yes    | Kyampisi  | Buto            | 16/10/2000    |
| 45. Mr. Kato Moses        | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Sekamuli  | Kito            | 17/10/2000    |
| 46. Mr. Waswa Sewagudde   | No  | No  | No  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Kibibi Kisogozi | 20/10/2000    |
| 47. Mr. A. Kibuye         | No  | No  | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Nkuruze         | 20/10/2000    |
| 48. Mr. Ssali Moses       | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiteme    | Kikonda         | 21/10/2000    |
| 49. Mr. Kanyike E         | Yes | Yes | Yes | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiteme    | Kasolo          | 21/10/2000    |
| 50. Mr. Kyobe             | No  | No  | No  | No                  | Yes    | Yes   | Yes   | Yes    | Kiteme    | Kyotamugavvu    | 21/10/2000    |

G, W, N columns specify if the farmer's records are available in growth, weevil and nematode files.



**Table 1b – Codes used in recording labour activities**

|   |
|---|
| Name of farmer  |
| Village   |
| Parish  |
| District (site)   |
| Trial type 1=enhanced plant nutrition ; 2=promotion trial   |
| Farm Number   |
| Labour 1=family labour 2=hired labour   |
| Activity 1=land clearing 2=hole preparation 3=planting 4=weeding 5=mulching 6=manure 7=watering<br>8=pruning 9=ploughing 10=spraying herbicide 11=de-leafing<br>12=digging trenches 13=manure transporting 14=grass cutting 15=irrigation |
| Gender 1=female 2=male  |
| Age   |
| Number of days  |
| Number of hours   |



**Table 1c - Luwero benchmark site**  
**Information on crop areas and some demographic variables**

|  |                                   |
|--|-----------------------------------|
| <b>Background variables</b>  | V38                               |
|  | V39                               |
| V1 Site  | V40                               |
| V2 Trial type (1=enhanced plant nutrition<br>as control of diseases;<br>2=promotion of exotic bananas) |                                   |
| V3 Farmer number   | <b>Land under cash crops 2000</b> |
| V4 Farmer name   | V41 Coffee acres 2000             |
| V5 Date of data collection   | V42 Kayinja acres 2000            |
|  | V43 Maize                         |
|  | V44 G Nuts                        |
|  | V45 vegetables                    |
| <b>Demographic</b>   | V45a Ndizi                        |
|  | V45b Bugoya                       |
| V6 Sex   | V45c beans                        |
| V7 Age   | 45d cassava                       |
| V8 education   | 45e fruits                        |
| V9 Family size   | 45f potatoes                      |
|  |                                   |
| <b>Farming system</b>  | <b>Land under cash crops 2001</b> |
|  | V46 Coffee acres 2001             |
| V10 Size of land holding (acres)   | V47 Kayinja acres 2001            |
|  | V48 Maize                         |
|  | V49 G Nuts                        |
|  | V50                               |
| <b>Land under food crops 2000</b>  | <b>Land under cash crops 2002</b> |
| V11 maize acres 2000   | V51 Coffee acres 2002             |
| V12 beans acres 2000   | V52 Kayinja acres 2002            |
| V13 cassava acres 2000   | V53 Maize                         |
| V14 potato acres 2000  | V54 G Nuts                        |
| V15 peas acres 2000  | V55                               |
| V16 ground nuts  |                                   |
| V17 yams   |                                   |
| V18 irish potatoes   |                                   |
| V19  |                                   |
| V20  |                                   |
|  |                                   |
| <b>Land under food crops 2001</b>  |                                   |
| V21 maize acres 2001   |                                   |
| V22 beans acres 2001   |                                   |
| V23 cassava acres 2001   |                                   |
| V24 potato acres 2001  |                                   |
| V25 peas acres 2001  |                                   |
| V26 irish potatoes   |                                   |
| V27 yams   |                                   |
| V28  |                                   |
| V29  |                                   |
| V30  |                                   |
|  |                                   |
| <b>Land under food crops 2002</b>  |                                   |
| V31 maize acres 2002   |                                   |
| V32 beans acres 2002   |                                   |
| V33 cassava acres 2002   |                                   |
| V34 potato acres 2002  |                                   |
| V35 peas acres 2002  |                                   |
| V36  |                                   |
| V37  |                                   |



## R7567 (Banana IPM Project) - PROTOCOL AK2

**TITLE:** Evaluation of improved exotic banana cultivars on farmer fields against pests and diseases and performance with respect to agronomic characteristics and post harvest qualities

**Lead Scientists:** Kangire A, Nowankunda K and Tushemereirwe W.

**Activity Leader(s):** Kangire, A., Ngambeki, D., Balekye, A.

**Project Funding:** DFID Crop Protection Programme

**Research partners:** CABI UK and Natural Resources Institute, Univ. of Reading

**Start and end dates:** 2000 – 2003

### Background:

From on-station germplasm evaluation activities, several genotypes with resistance to weevils, Black Sigatoka and nematodes and promising post harvest characteristics have been identified. These still require evaluation with farmers.

### Objectives

1. To evaluate the performance of introduced cultivars and their response to pests and diseases
2. To assess the acceptability of the cultivars according to farmers' criteria.

### Materials and methods

- (i) Location: Bamunanika sub-county in the Luwero district.
- (ii) Choice of farmers: Team of researchers mobilized communities by going from village to village in all the six parishes of Bamunanika sub-county, Luwero benchmark site. From each village, groups of farmers with their village local leaders selected four persons to represent each village community at the farmers' participatory planning meeting. In the village, a 4 person delegation was selected in such a way so as to represent (a) the civic village leadership, bottom, middle and top; (b) socio-economic strata as well as gender (men and women) representatives. Further details concerning the involvement of scientists, collaborators, relevant stakeholders, and farmers in the overall research programme, and the identification of possible technological interventions, with full farmer participation, to address farmers priority constraints, can be found in the Luwero Benchmark site annual report (July 2000-May 2001).
- (iii) Farmers participating in trial: 13 farmers from 6 parishes (See Table 2a for listing).
- (iv) Planting date: 25<sup>th</sup> April to 25<sup>th</sup> May 2001
- (v) Cultivars: FHIA 25, SABA, PITA 8, PITA 14, PITA 17, Kisansa (or Mbwazirume) – a local check. These cultivars have been multiplied as tissue culture material and were made available to the participating farmers in Luwero.
- (vi) Trial layout: 12 plots per farm, i.e. 2 plots, one with mulch and one without mulch for each of the 6 cultivars, laid out as a split-plot experiment with cultivars on main plots and mulch treatment on the sub plot. In each plot, there were 10 mats. Plot size was 36 x 30 m<sup>2</sup> for each farm.
- (vii) Trial management/Inputs: Management was by farmers, but much of the inputs required (other than labour) was provided by the researcher. One field assistant (FA), by the name of Mugerwa, on-site in Luwero, was visiting each farmer once in two weeks.



- (viii) Data collection process: Information on labour inputs and harvests (bunch weight, data of harvest, number of hands, number of leaves) are recorded by farmers. FA copies this information into his own recording sheets. These are then brought back to Luwero site co-ordinator (Dezi Ngambeki) once in two weeks. Note: there are two sets of recording sheets, when one set comes back, the other set gets taken back to the field. Mugerwa also collects information on sigatoka, i.e. the number of the youngest leaf affected.

The economic data are retained by Dezi. The biological data are passed to the lead scientist for the trial.

Types of data collected:

(i) *Biological assessments:*

*Farmer records at harvest:* date of harvest, bunch weight, number of hands, number of leaves.

*Researcher records at flowering time:* Flowering date, number of plants per mat, girth at 1 metre, height of plant, number of leaves at flowering, number of the youngest leaf spotted, BSV rate (0-3), Fusarium rating (1-6).

(ii) *Disease and pest assessments:*

No assessments were to be made because the cultivars are still being evaluated. However, nematode data (necrosis and dead roots, population density) have been collected.

(iii) *Socio-economic information:*

*Farmer records during the trial:* labour inputs (whether by family or from outside) for each activity, and by person (with gender and age); management activities, e.g. land clearing, ploughing, manure application, weeding, mulching, pruning, etc., and amounts of family labour used for these activities.

More data available with Dr. Ssenyonga.

Dr Ssenyonga's team is collecting data for all Luwero farmers on farm management activities and on labour and other inputs. This monitoring data collection, once a fortnight, began in the last week of March 2002 and will be continued until August 2002. The data is sitting in the office across the way in great big piles, waiting to be computerised. Enoch Kikulwe is responsible for this information.

Dr Ssenyonga has also collected a lot of socio-economic information from all the Luwero farmers through a formal (several page) questionnaire. This includes information such as household characteristics (gender, age, etc), number of years of general farming, number of years of banana farming, major sources of livelihoods and their importance rank, land size under bananas, etc. It is expected that the data entry will be completed in mid August. Enoch will then clean the data base and start analysing the data with inputs from Dr Ssenyonga and Philip Ragama.

A listing of **all** farmers in the Bamunanika sub-county is available with Yusuf, categorised by the type of trial that the farmer is involved in, as shown below.

| Code   | Description of trial                                      |
|--------|---|
| AFHM   | Alternative (Fertilizer/Herbicides) Management            |
| EBCD   | Exotic Banana Cultivar Dissemination                      |
| EEBC   | Evaluation of Exotic Banana Cultivars                     |
| EPNLMP | Enhanced Plant Nutrition as a Leaf spot Management option |
| ESWMB  | Economics of Soil and Water Management on Banana          |
| ORMBCA | Own Resources to Manage Bananas as a Commercial Activity  |



(v) *Farmer acceptability assessments (Post-harvest qualities, uses and acceptability)*

Both the participating and non-participating farmers were mobilised, at parish level, through their groups to a meeting at or near one of the participating farmers. At each meeting farmers were requested to list:

- The major uses of bananas in the area
- The major characteristics they considered important for each use category. These were later used to design data sheets.
- Also, the farmers discussed their own experience with the exotic and other bananas and indicated the potential uses of the various cultivars according to their own criteria. Farmers cooked (by steaming and boiling) and prepared crisp from the various genotypes and tested them. Their perceptions were recorded on a 6-point hedonic scale translated into local language where 6 = Extreme liking and 1 = Extreme dislike

All cultivars had been tested for cooking using affective (consumer ) methods. A minimum of 24 farmers is recommended for on-farm affective tests. In these tests, a minimum of 309 farmers was used.

At each panel sitting, the farmers were divided in to two groups, each group prepared the same genotypes but used different cooking methods (Steaming and Boiling in source). The samples from each group were then evaluated by the all farmers. Taste and flavour , texture, colour and general acceptability were of the cooked samples were evaluated.

More information on other utilisation methods is still to be collected from the farmers.

**Protocol filename:** L\_EV\_Protocol\_AK2.doc

**Table 2a - List of farmers participating in the Evaluation Trial**

| Name                    | G   | W  | N   | Parish    | Village     | Planting date |
|-------------------------|-----|----|-----|-----------|-------------|---------------|
| 104. Kabunga Viola      | Yes | No | Yes | Kyampisi  | Ndalimu     | 26/04/2001    |
| 105. Mubiru Joseph      | Yes | No | Yes | Kyampisi  | Kikabya     | 26/04/2001    |
| 106. Kisawuzi           | No  | No | Yes | Sekamuli  | Wabuyinja   | 25/04/2001    |
| 107. Kiwagu J.          | No  | No | Yes | Sekamuli  | Kasiribiti  | 25/04/2001    |
| 108. Semiryango Damiano | Yes | No | Yes | Kibanyi   | Kidolindo   | 28/04/2001    |
| 109. Serwada Denis      | Yes | No | Yes | Kibanyi   | Kanjuki     | 30/04/2001    |
| 110. Sendaula Kassim    | Yes | No | Yes | Kibanyi   | Kyanika     | 28/04/2001    |
| 111. Ssetimba Vicent    | Yes | No | Yes | Kiteme    | Butalyamisa | 04/05/2001    |
| 112. Muwonge Matiya     | Yes | No | Yes | Kiteme    | Malungu     | 04/05/2001    |
| 113. Musasizi           | No  | No | Yes | Kiteme    | Buwanuka    | 30/04/2001    |
| 114. John Kigozi        | Yes | No | Yes | Mpologoma | Mpungu      | 30/04/2001    |
| 115. Nakamya            | No  | No | Yes | Kibirizi  | Ggavu       | 23/05/2001    |
| 116. Gladys Nakito      | Yes | No | Yes | Kibirizi  | Busamba     | 30/04/2001    |

G, W, N columns specify if the farmer's records are available in growth, weevil and nematode files.

Note: cultivars planted are: Kisansa, PITA 14, Saba, FHIA 25 and PITA 17.



## R7567 (Banana IPM Project) - PROTOCOL AK3

|                             |  |
|-----------------------------|--|
| <b>TITLE:</b>               | Promotion of approved exotic banana cultivars to improve productivity in Luwero District |
| <b>Lead Scientists:</b>     | Kangire A, Nowankunda K  |
| <b>Activity Leader(s):</b>  | Kangire, A., Ngambeki, D., Balekye, A.   |
| <b>Project Funding:</b>     | DFID Crop Protection Programme   |
| <b>Research partners:</b>   | CABI UK and Natural Resources Institute, Univ. of Reading                                |
| <b>Start and end dates:</b> | 2000 – 2003  |

### Background:

Banana is considered the most important food security crop in Uganda grown on over 30% of utilisable land (1.3-1.5 million ha). It is estimated that more than 75% of the population in Uganda rely on bananas. However, there has been a noted decrease in banana productivity especially in central and eastern Uganda, despite an increase in total acreage.

A number of selected exotic banana cultivars which have been recently released, e.g. Kabana 1, Kabana 3, Kabana 4 and Kabana 5, have been found to be high yielding and have been evaluated in some parts of Luwero. However, their data was collected from a restricted sample and considered insufficient. There is therefore a need to further validate, with a larger sample of farmers, the performance, relevance and acceptability of exotic banana cultivars in the area, and then multiply the respective planting materials for scaling up the distribution to more farmers.

### General objective

To improve banana productivity in Luwero district

### Specific objectives

1. To assess exotic banana cultivars for disease and pest resistance and agronomic performance and farmers' criteria in Luwero district.
2. Multiplication and dissemination of planting materials to farmers in Luwero and its environs.

### Expected outputs

1. High yielding, pest and disease resistant banana cultivars identified.
2. Appropriate banana cultivars recommended and selected with farmers' approval.
3. Planting materials of acceptable cultivars disseminated in Bamunanika sub-county.

### Materials and methods

- (i) Location: Bamunanika sub-county in the Luwero district.
- (ii) Choice of farmers and sites: See Luwero Benchmark site report for the period July 2000 – May 2001 for details concerning stakeholder participation, choice of farmers and choice of sites.
- (iii) Farmers participating in trial: 29 farmers (see Table 3a for a listing) from 6 parishes.
- (iv) Planting date: October 2000
- (v) Cultivars: FHIA 01 (Kabana 1), FHIA 17 (Kabana3), FHIA 23 (Kabana4), KM 5 (Kabana 5), Kisansa or Mbwazirume. These cultivars have been multiplied as tissue culture material and were made available to the participating farmers in Luwero.
- (vi) Trial layout: Total area used within each farm was  $\frac{1}{4}$  (30 x 30 m<sup>2</sup>) or a  $\frac{1}{8}$  acre of land. There were 10 plants per sub-plot, spaced 3m apart. At least 4 farmers (replicates) were used as representatives of each of the parishes used in this trial. The trial was a split-plot



design (each farm as replicate) with the cultivars placed in the main plot, while application of manure/mulch or not was the sub-plot. Thus each farm was divided into two parts, i.e. main plots (see below), one of which was to receive manure and mulch treatment and the other no manure treatment. The five cultivars (Kabana 1 Kabana 3, Kabana 5 and Kisansa or Mbwarzirume) were randomly distributed in the two sections with ten plants (mats) per plot.

However, plant material ran short for some of the farms, so in these farms, only one main plot was used and it was left to the farmer whether he would mulch all 5 sub-plots or leave all sub-plots unmulched. Thus some farmers grew 100 plants (2 main plots), while others grew 50 plants (one main plot).

For purposes of disseminating planting materials over a wider community, it was felt that only 10 fields in different villages were sufficient to constitute a replicated trial while the rest 19 fields were left as non- controlled plots primarily for purposes of dissemination.

After trial establishment the participating farmers were trained in trial management in December 2000. The trial layout as initially planned is given below.

|         |         |                        |         |                        |
|---------|---------|------------------------|---------|------------------------|
| FHIA 01 | KM 5    | Kisansa or Mbwarzirume | FHIA 23 | FHIA 17                |
| KM 5    | FHIA 23 | FHIA 17                | FHIA 01 | Kisansa or Mbwarzirume |

|             |  |
|-------------|--|
| Mulched     |  |
| Not mulched |  |

(vii) Trial management/Inputs: The scientist provided the plantlets to the farmers while the farmers in turn provided the land for hosting the trial, labour for management of the trial and manure/mulch. One field assistant (FA), by the name of Mugerwa, on-site in Luwero, visiting each farmer at least once in two weeks.

(viii) Data collection process: Information on labour inputs are recorded by the farmers. The FA records the biological measurements together with the farmer. If farmer has done the recording him/herself, the FA copies this information into his own recording sheets. These are then brought back to Dezi once in two weeks. (Note: there are two sets of recording sheets, when one set comes back; the other gets taken back to the field). Mugerwa also collects information on sigatoka, i.e. the number of the youngest leaf affected.

Alex Berekye (with 3 technical assistants) collects information on nematodes and weevils. Detailed disease (BSV) information is collected by the two PhD students (Gerome Kubiriba and Charles Murekezi).

Dezi receives all the data. The economic data are retained by Dezi. The biological data are passed to the lead scientist for the trial.

## Data being collected

### *Biological data by cultivar type*

- Planting – shooting period
- Plant growth parameters (Sucker emergence, Girth, Height, Total leaves,)
- Snapping
- Plant tissue and soil nutrient analysis
- Flowering date, cycle, number of leaves, the youngest leaf spotted



- Yield: Bunch weights, number of hands, number of leaves , date at harvest
- Disease and pest monitoring (weevils, BSV , fusarium wilt )

#### *Socio Economic data*

- Farmer category, sex, age, education , land size , land under bananas
- Farm labour – source of labour (family , hired ) , labour inputs / farm activity / age / gender / days / hours per day worked
- Farm activities – land clearing, ploughing, hole preparation, planting, weeding, manure composting carrying and application, mulching ,making trenches , pruning , intercropping , desuckering , general sanitation , harvesting and transport
- Inputs type (e.g. cow dung, compost manure, mulch, coffee husks) , source of input , cost of input , methods of application and rate of application.

#### *Sucker distribution*

- Date, cultivar type, number of suckers, name of beneficiary, village, parish and sub county of the beneficiaries.

#### *Farmer acceptability assessments:*

Farmers from the area invited to participate in meetings to determine acceptability of cultivars.

Although INIBAP recommendation was to use 24 farmers in on-farm studies (and 15 in on-station studies), the scientist involved (Kephass Nowakunda) had used a minimum of 30 farmers.

Farmers had been divided in to two groups, and 2 farmers in each group had prepared the samples which were then evaluated by the other farmers. Farmers were asked to score each cultivar on their texture (too soft: score 5, to very hard: score 1), and on the basis of taste, colour and smell/odour, the latter two being judged after the bananas were cooked.

Farmers were also trying out different ways of preparing the cultivars and noting down their views in a recording book. This information was still to be collected from the farmer.

**Protocol filename:** L\_PR\_Protocol\_AK3.doc



**Table 3a. List of farmers participating in the Promotion Trial**

| Name                              | Growth<br>Cycle 1 | Growth<br>Cycle 2 | Weevils |      | Nematodes |      | Socio-economic data |        |       |       |        | Parish    | Village     | Planting<br>date |
|-----------------------------------|-------------------|-------------------|---------|------|-----------|------|---------------------|--------|-------|-------|--------|-----------|-------------|------------------|
|                                   |                   |                   | 2002    | 2003 | 2002      | 2003 | Suckers             | Inputs | Crops | Hired | Family |           |             |                  |
| 1. Abdul Kasozi                   | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Kangulumira | 11/10/2000       |
| 2. Joseph Katende                 | No                | No                | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Mpologoma   | 11/10/2000       |
| 3. Joyce Nagita                   | No                | Yes               | No      | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Mpologoma   | 10/10/2000       |
| 4. Godfrey Lubega                 | No                | Yes               | Yes     | No   | Yes       | Yes  | No                  | No     | No    | No    | No     | Mpologoma | Kangulumira | 11/10/2000       |
| 5. Semakula Moses                 | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | No    | Yes    | Mpologoma | Mityebiri   | 6/10/2000        |
| 6. Efrance Naluyima               | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Mpologoma | Mityebiri   | 6/10/2000        |
| 7. Yusuf Kasirye                  | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibanyi   | Kibanyi     | 10/10/2000       |
| 8. Hussein Matovu                 | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | No    | Yes    | Kibanyi   | Kalwe       | 24/10/2000       |
| 9. Ndikora Stanslus               | Yes               | Yes               | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibanyi   | Kawuku      | 24/10/2000       |
| 10. R. Guyeneza                   | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiteme    | Kiteme      | 16/10/2000       |
| 11. B. Sebandeke                  | No                | No                | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiteme    | Kasolo      | 19/10/2000       |
| 12. Katende                       | No                | No                | No      | No   | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Sekamuli  | Kakola      | 20/10/2000       |
| 13. Raphael Mwanje                | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Sekamuli  | Kito        | 19/10/2000       |
| 14. Kakoza Deo (dropped?)         | No                | No                | No      | No   | No        | No   | No                  | No     | No    | No    | No     | Sekamuli  | Kito        | 19/10/2000       |
| 15. Nakitende Florence (dropped?) | No                | No                | No      | No   | No        | No   | No                  | No     | No    | No    | No     | Sekamuli  | Kito        | 19/10/2000       |
| 16. Elias Sentamu                 | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | No    | Yes    | Sekamuli  | Nakulabye   | 16/10/2000       |
| 17. Milly Nabalinde               | No                | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Kibirizi    | 23/10/2000       |
| 18. Justin Mulwana                | No                | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Kibirizi    | 23/10/2000       |
| 19. Moses Kasozi                  | No                | Yes               | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Nkuruze     | 23/10/2000       |
| 20. Mugambi Karanzi (DEAD)        | No                | Yes               | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Nkuruze     | 23/10/2000       |
| 21. L. Tomusange                  | No                | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | No    | Yes    | Kibirizi  | Kisanga     | 25/10/2000       |
| 22. Sowedi Kijambo                | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kibirizi  | Kisanga     | 25/10/2000       |
| 23. Kavuma Sekanolya              | No                | Yes               | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | No    | Yes    | Kibirizi  | Kisanga     | 26/10/2000       |
| 24. Robert Semakula               | Yes               | Yes               | No      | Yes  | No        | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiyampisi | Kakira      | 5/10/2000        |
| 25. Fred Gongebwa                 | No                | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | No    | Yes    | Kiyampisi | Magogo      | 24/10/2000       |
| 26. Mulyazawo                     | Yes               | Yes               | Yes     | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiyampisi | Magogo      | 24/10/2000       |
| 27. Jamil Kigongo                 | No                | Yes               | No      | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiyampisi | Buto        | 26/10/2000       |
| 28. Kasim Sekweya                 | Yes               | Yes               | No      | Yes  | Yes       | Yes  | Yes                 | Yes    | Yes   | Yes   | Yes    | Kiyampisi | Lutete      | 26/10/2000       |
| 29. Kizito Mulengera              | No                | Yes               | No      | Yes  | No        | Yes  | Yes                 | No     | Yes   | No    | Yes    | Kyampisi  | Kakira      | 27/10/2000       |
| 30. Kagwa E                       | No                | No                | No      | No   | No        | No   | No                  | No     | No    | No    | No     | Mpologoma | Kiyunga     | 28/10/2000       |

G, W, N columns specify if the farmer's records are available in growth, weevil and nematode files.



**Table 3b**  
**Codes for labour data**

|   |
|---|
| Name of farmer  |
| Village   |
| Parish  |
| District (site)   |
| Trial type 1=enhanced plant nutrition ; 2=promotion trial   |
| Farm Number   |
| Labour 1=family labour 2=hired labour   |
| Activity 1=land clearing 2=hole preparation 3=planting 4=weeding 5=mulching 6=manure<br>7=watering 8=pruning 9=ploughing 10=spraying herbicide 11=de-leafing<br>12=digging trenches 13=manure transporting 14=grass cutting 15=irrigation |
| Gender 1=female 2=male  |
| Age   |
| Number of days  |
| Number of hours   |



**Table 3c - Luwero benchmark site**  
**Information on crop areas and some demographic variables**

**Background variables**

V1 Site  
V2 Trial type (1=enhanced plant nutrition  
as control of diseases;  
2=promotion of exotic bananas)  
V3 Farmer number  
V4 Farmer name  
V5 Date of data collection

V30

***Land under food crops 2002***

V31 maize acres 2002  
V32 beans acres 2002  
V33 cassava acres 2002  
V34 potato acres 2002  
V35 peas acres 2002

**Demographic**

V6 Sex  
V7 Age  
V8 education  
V9 Family size

V36  
V37  
V38  
V39  
V40

**Farming system**

V10 Size of land holding (acres)

***Land under cash crops 2000***

V41 Coffee acres 2000  
V42 Kayinja acres 2000  
V43 Maize  
V44 G Nuts  
V45 vegetables  
V45a Ndizi  
V45b Bugoya  
V45c beans  
45d cassava  
45e fruits  
45f potatoes

***Land under food crops 2000***

V11 maize acres 2000  
V12 beans acres 2000  
V13 cassava acres 2000  
V14 potato acres 2000  
V15 peas acres 2000  
V16 ground nuts  
V17 yams  
V18 irish potatoes  
V19  
V20

***Land under cash crops 2001***

V46 Coffee acres 2001  
V47 Kayinja acres 2001  
V48 Maize  
V49 G Nuts  
V50

***Land under food crops 2001***

V21 maize acres 2001  
V22 beans acres 2001  
V23 cassava acres 2001  
V24 potato acres 2001  
V25 peas acres 2001  
V26 irish potatoes  
V27 yams  
V28  
V29

***Land under cash crops 2002***

V51 Coffee acres 2002  
V52 Kayinja acres 2002  
V53 Maize  
V54 G Nuts  
V55



## R7567 (Banana IPM Project) - PROTOCOL AK4

|                             |  |
|-----------------------------|--|
| <b>TITLE:</b>               | Introduction and dissemination of approved exotic banana cultivars in Masaka district. |
| <b>Lead Scientists:</b>     | Kangire, A.  |
| <b>Activity Leader:</b>     | Kangire, A.  |
| <b>Project Funding:</b>     | DFID Crop Protection Programme   |
| <b>Research partners:</b>   | CABI UK and University of Reading  |
| <b>Start and end dates:</b> | 2000 – 2003  |

### Background

During the Banana on-farm research review and planning workshop held at Kisekka subcounty in July 2000, farmers expressed high demand for improved exotic bananas which are high yielding and disease resistant. Over 150 farmers at the Kisekka bench mark site applied to evaluate the new varieties such as FHIA 17 (Kabana 3) locally nick named "OFWONO", a named acquired due to the giant bunch produced by this cultivar. To begin with, three exotic cultivars were introduced at the site for farmer evaluation and multiplication.

### Objective

To introduce and disseminate new improved cultivars resistant to pests and diseases, and evaluate them further for agronomic performance and consumer acceptability for different aspects of utilisation in the area. The major impact of the trial at the end was to be the number of suckers disseminated to other farmers at the site.

### Materials and Methods

- (i) Location: Kisseka sub-county in the Masaka district.
- (ii) Choice of farmers: Farmers were randomly chosen from the 150 applications made for dissemination of three chosen cultivars. The applications were made following meetings where the cultivars were introduced and evaluated for taste flavour, colour and texture. A utilisation package was introduced with a demo of what can be done with these cultivars. At each meeting, 2 preparations of each of 2 cultivars were introduced. Similar follow-on meetings were attended by both participating and non-participating farmers. Each meeting was held on three consecutive days, with participation increasing from day 1 to day 3.
- (iii) Farmers participating in trial: 37 farmers from 7 parishes. (Table at the end of this document gives a listing)
- (iv) Planting date: October 2000
- (v) Cultivars: FHIA 17 (Kabana 3), FHIA 23 (Kabana 4), KM 5 (Kabana 5). These cultivars have been multiplied as tissue culture material and were made available to the participating farmers in Kisseka sub-county. The plants have already attracted more attention in the community due to their fast and vigorous growth. More farmers have applied for planting material.
- (vi) Trial layout: Each farmer received 5 plants of each cultivar for planting.  
  
Total area used within each farm was ????. The planting was done with plants spaced XX(?) metres apart.
- (vii) Trial management/Inputs: Management by farmers. Field assistant (FA) was Sulait Ddungu.



(viii) Data collection process: Information collected largely by the farmers.

Types of data collected and status of the data:

**(i) Biological assessments (includes some disease information on leaf spot):**

*Farmer records at flowering time and at harvest:* plant/mat no., cultivar, flowering date, girth (cms), height (cms), total number of leaves at flowering, number of the youngest spotted leaf, harvest date, total number of leaves at harvest, bunch weight (kg), number of clusters. *Note: Eventually (due to Lead Scientist being shifted to work on coffee), data were only available for bunch weights, number of days to flowering, number of days to harvest and number of leaves at harvest.*

**(ii) Distribution of suckers:**

Farmers were collecting this information. But the information was never actually systematically collected from the farmer, so no data is available.

**(iii) Socio-economic information:**

Not collected. But there is information from a 1998 socio-economic survey of baseline information.

**(iv) Farmer acceptability assessments:**

Data collection process

Meetings were organised for farmers and in 2002 at Parish level to review Banana activities in Kisekka, Masaka. At the end of every meetings palatability tests were carried out on the following products:

- Steamed Fhia 17
- Steamed Km5
- Porridge from a mixture of banana flour and other flour commonly used
- Thick-porridge, *ugali*, from a mixture of banana flour and millet flour

Banana flour was made from dried bananas of varieties such as Matooke, Kabana 4, Kabana 3 which are not astringent.

Results were reported scores on Mouthfeel, Taste, Colour, Flavour, Acceptability on a hedonic scale (1=poor, 2=fair, 3=good, 4=very good, 5=excellent)

**Data Status:**

Unknown. Note that the data available in the sub-directory \IPM(R7567)\_Masaka\_M\_Utilisation refer to a study conducted by Mille Pikke and does not relate to the cultivars grown in this trial.

**Data Analysis:** Only the data on bunch weights, number of days to flowering, number of days to harvest and the number of leaves at harvest, were available for data analysis. The corresponding analysis programs appear in files

**Protocol filename:** M\_PR\_Protocol\_AK4.doc



**Table 4a****List of farmers participating in the Promotion Trial at Kisseka**

| <b>Name</b>                 | <b>Parish</b> | <b>Village</b> | <b>Planting date</b> |
|-----------------------------|---------------|----------------|----------------------|
| 1. Munaugunda               | Kiwangala     | Kiwangala      | October 2000         |
| 2. Kayinga Francis          | Kiwangala     | Kyanukuzi      | October 2000         |
| 3. Bakabulindi Hasain       | Kiwangala     | Migongo        | October 2000         |
| 4. Kayira Augustin          | Kiwangala     | Kavule         | October 2000         |
| 5. Luswata Joseph           | Kiwangala     | Kanku          | October 2000         |
| 6. Kabagamba Lei            | Kiwangala     | Lukindo        | October 2000         |
| 7. Mawegye Abdu             | Kiwangala     | Lukindo        | October 2000         |
| 8. Kisauzi Habibu           | Ngereko       | Kibumbi        | October 2000         |
| 9. Bukenya Evalisto Salongo | Ngereko       | Ngereko        | October 2000         |
| 10. Mrs. Bizimungu          | Ngereko       | Ngereko LC1    | October 2000         |
| 11. Jane Musazi             | Ngereko       | Ngereko        | October 2000         |
| 12. Naluga Milly            | Ngereko       | Manja B        | October 2000         |
| 13. Kayondo Godfrey         | Ngereko       | Buyoga         | October 2000         |
| 14. Ssempala Willy          | Ngereko       | Buyoga         | October 2000         |
| 15. Wasswa Milton           | Ngereko       | Buyoga         | October 2000         |
| 16. Ssetuba S               | Busubi        | Kalagala       | October 2000         |
| 17. Mary Itiman             | Busubi        | Kalagala       | October 2000         |
| 18. Silvia Kalanzi          | Busubi        | Kalagala       | October 2000         |
| 19. Sebowa Joseph           | Kankamba      | Kankamba       | October 2000         |
| 20. Ssemanda Daneil         | Kankamba      | Kiseka         | October 2000         |
| 21. Ssula Paul              | Kankamba      | Kiseka         | October 2000         |
| 22. Sulait Ddungu           | Kankamba      | Bukumbura      | October 2000         |
| 23. Daudi Kavuma            | Kankamba      | Bukumbura      | October 2000         |
| 24. Siraji Zziwa            | Kikenene      | Buyiki         | October 2000         |
| 25. Siza Kimbugwe           | Kikenene      | Kikenene       | October 2000         |
| 26. Kasamba J.W.            | Kikenene      | Nakawanga      | October 2000         |
| 27. Sseremba M              | Kikenene      | Lubanda        | October 2000         |
| 28. Namatovu Gerad          | Kikenene      | Lubanda        | October 2000         |
| 29. Lubambula               | Kikenene      | Nakawanga      | October 2000         |
| 30. Resty Bukenya           | Nakalembe     | Nakalembe      | October 2000         |
| 31. Swaifu Sebanakita       | Nakalembe     | Nakalembe      | October 2000         |
| 32. Posiano Lubega          | Nakalembe     | Nakalembe      | October 2000         |
| 33. Ndagire                 | Nakalembe     | Nakalembe      | October 2000         |
| 34. Namwandu Katende        | Nakatete      | Ddongwa        | October 2000         |
| 35. Kalule Fugensio         | Nakatete      | Ddongwa        | October 2000         |
| 36. Namuyimba Edward        | Nakatete      | Bunyere        | October 2000         |
| 37. Kaluna Matovu           | Nakatete      | Ddegeya        | October 2000         |



## R7567 (Banana IPM Project) - PROTOCOL AK5

|                             |  |
|-----------------------------|--|
| <b>TITLE:</b>               | Etiology and management of matooke wilt          |
| <b>Lead Scientists:</b>     | Kangire, A. (working with Mike Rutherford, CABI) |
| <b>Activity Leader:</b>     | Kangire, A.                                      |
| <b>Project Funding:</b>     | DFID Crop Protection Programme                   |
| <b>Research partners:</b>   | CABI UK and Natural Resources Institute          |
| <b>Start and end dates:</b> | 2000 – 2003                                      |

### Background

Previous studies undertaken by the NBRP indicated that matooke wilt is a banana disorder that exclusively appears around homesteads, in western Uganda highlands (above 1300 metres above sea level), with a long history of dumping uncomposted household refuse, or kraals where animals deposit their excreta such as dung and urine. It was also found that all cultivars locally grown in Uganda are indiscriminately affected by this disorder. Plants growing around heavily fertilised areas especially with animal excreta like urine (human or domestic animals), eventually developed wilt symptoms more or less similar to those of *Fusarium* wilt. However, in this case *Fusarium oxysporum* f.sp. *cubense* (FOC), the causal agent of *Fusarium* wilt (Panama disease), was never isolated as a causal agent. Moreover, banana planting materials affected with matooke wilt (disorder), recovered when transferred to areas far from homesteads or animal kraals, which is not the case with *Fusarium* wilt.

Preliminary results from studies undertaken in western Uganda between 1994-1998, found that farmers who practiced proper composting of manure as advised by the agricultural staff, and constant roguing of infected banana mats, had matooke wilt incidence considerably reduced on their farms. However, these studies could not resolve the causal agent, or if at all a pathogen was involved, although it was postulated that causes other than pathological e.g. soil nutrient imbalances were most likely involved.

### Objectives:

To undertake studies western Uganda, with a view to developing management technologies for controlling this disorder while also identifying the causal agent.

### Materials and Methods.

- i) *Location:* western Uganda districts of Mbarara, Bushenyi and Ntungamo districts.
- ii) *Choice of farmer:* The choice of farmer was based on the availability of the disorder on his farm and willingness to participate.
- iii) *Farmers participating:* Initially 10 farmers were involved, but currently only seven (7) are still participating after three dropped out, due to poor application of methodologies as given by the researchers.
- iv) *Trial layout:* At each farm, two equal plots (treatments) one being for proper management of the matooke wilt disorder by roguing out infected mats supplemented with proper composting of manure in the plot, and another section of the farm being left unrouged and no particular treatments were imposed. These plots were derived by splitting the affected plot (usually on the lower side of the homestead), into two parts with approximately equal number of mats.
- v) *Starting date:* May 2001.

### Trial description and data collection.

While it was of fundamental importance to identify the causal agent of matooke wilt on bananas, a management strategy involving on-farm trials, to control this disorder was also adopted, basing on previous data. Farms were selected and trials established in the districts of Bushenyi, Mbarara and Ntungamo during the month of May 2001. At each farm, two plots (treatments) one being for proper management of the disease by roguing out infected mats supplemented with proper composting of manure, and another section of the farm being left unrouged with no particular treatment imposed.



These plots were derived by splitting the affected plot (usually on the lower side of the homestead), into two parts with approximately equal number of mats. In cases where wilt disorder was low or equal split was impractical, the treated section was always taken to be with the largest incidence at the start of the trial.

Initially, before imposing management treatments, baseline data in terms of disease incidence and severity and bunch yield in the treated and the non-treated plots of the farms was recorded and thereafter, infected mats were marked with blue paint, while healthy ones were marked with white paint for subsequent follow up studies. Each of the marked mat was also given a number tag for further identification.

The farmer was shown how to remove the number tag, which was attached to a waterproof polythene string, and transfer it to the immediate follower sucker of the same mat, whenever a mature bunch is harvested. In this case, the researcher was able to follow up developments of the matooke wilt disorder on each subsequent sucker and each particular mat. For easy data collection of wilt disorder, each mat was recorded as one plant no matter whether two plants were found to be affected by the disease or not.

The farmers were also taught proper methods of composting their household residues with the help of a soil science scientist, and later how to properly apply the refuse in the field. Furthermore, a demonstration for compost management was established at each farm with the help of a soil scientist who guided the farmers on how to compost their household refuse. In this case, a three pit method was recommended in which sequential household refuse is treated through a decomposition process (as advised by the Soil Science Unit at Kawanda Agricultural Research Institute).

While wilt disorder incidence, severity and yield data was collected at every visit by the researcher, farmers were also requested to record the bunch weight whenever they harvested. Wilt incidence was based on a scale of 0–3 in which 0 represented absence of the wilt disorder, while 3 was extreme wilt severity as shown below.

| Wilt grade | Description of disorder  |
|------------|--|
| 0          | Plant appears healthy and may have a healthy bunch   |
| 1          | Some reduction in overall plant vigour and bunch size visible  |
| 2          | Obvious reduction in pseudostem and bunch size and fingers, plant stunting, discolouration of inner pseudostem sheaths, and outer leaf-sheath drying.        |
| 3          | Plant stunted, thin pseudostem, extensive streaking and drying of leafsheaths, distorted leaves, unpalatable bunch or reduced finger size. Plant may topple. |

Soil samples for nutrient analysis were also collected within and away from affected area for further nutrient analysis. For purposes of accuracy and consistency, the analysis of these samples was carried out at the University of Reading.

#### **Data status/ collected:**

Data on mat number, wilt grade, bunch weight already available on the computer. Wilt grade was based on a 0-3 scale as shown above and Bunch weight was in Kilogrammes and was collected from the treated and non-treated plots at each farm. The data was recorded at each visit taking particular reading of each number tag on each mat.

**Protocol filename:** Nt\_Protocol\_Matooke\_wilt\_AK5.doc



## R7567 (Banana IPM Project) - PROTOCOL AK6

**TITLE:** Evaluation of Cavendish banana cultivars

**Lead Scientists:** Kangire, A. and W.Tushemereirwe

**Activity Leader:** Kangire, A.

**Project Funding:** DFID Crop Protection Programme

**Research partners:** CABI UK and Natural Resources Institute, Univ. of Reading

**Start and end dates:** 2000 – 2003

### Background

In Uganda, banana consumption is largely limited to highland banana cultivars which are endemic to the region. Unfortunately, these cultivars are limited in utilization and in providing other products such as dessert or juice. Although other cultivars such as Gros Michel, Ney poovan and Pisang awak are available, they are highly susceptible to fusarium wilt and are less competitive on international markets such as in Europe and therefore of less economic value.

Previous work showed that Cavendish cultivars are resistant to fusarium wilt in Uganda, where only *Fusarium oxysporum* f.sp.*cubense* (FOC) race 1 has been identified. This attribute is important in that these cultivars are potential replacement for Gros Michel (Bogoya) which is highly susceptible to FOC race 1 in Uganda. Moreover, being the cultivars widely acceptable on the international market, Cavendish is a potential export crop for Ugandan farmers. Despite its resistance to fusarium wilt in Uganda and considerable high yields, Cavendish suffers from Sigatoka leaf spots in the lowlands (above 15°C) such as central Uganda where the disease is most common. This means that if Cavendish cultivars are to be grown in Uganda, it should be limited to the higher elevated areas (below 15°C), like western region (including Masaka and Rakai districts) where Sigatoka disease incidence is quite low. Evaluation of Cavendish cultivars was therefore done at Masaka, Mbarara /Ntungamo bench-mark sites:

### Materials and Methods

Location: Mbarara and Ntungamo districts.

Choice of farmer: willingness to participate.

Farmers participating: Initially 18 farmers in Ntungamo and 1 at Mbarara Stock farm.

Trial layout: At each farm, 3 Cavendish and Kabana 3 (FHIA 17) and Gros Michel as local check cultivars. The Cavendish cultivars were, Williams, Grand Nain and Chinese Cavendish (all received from South Africa), Kabana 3 and Gros Michel (which acted as local check). Each farm hosted six (6) tissue culture plantlets of each cultivar, spaced at 3mx3m.

Starting date: April 2001.

### Trial description.

Trials were established in Ntungamo and one at Mbarara Stock Farm in April 2001 to evaluate 3 Cavendish and Kabana 3 (FHIA 17) cultivars for their agronomic performance and resistance to pests and diseases. These were: Williams, Grand Nain and Chinese Cavendish (all received from South Africa), Kabana 3 and Gros Michel (which acted as local check). Each farm hosted six (6) tissue culture plantlets of each cultivar. A total of eighteen farmers representing all the parishes of Ntungamo sub-county (at Ntungamo benchmark site) and ten at Masaka benchmark site while one field at Mbarara Stock Farm, was used and each farm represented a single replicate. Spacing was 3mx3m and each farm was approximately Data on plant growth and disease development is currently being monitored on all the trials.

### Data status:

The following data is being collected by farmers together with a field assistant Steven Turyeija:

Fusarium wilt; Sucker emission date; Flowering date; Height at Flowering; Total leaves at flowering; Youngest leaf with leaf spot; Harvesting date; Bunch weight at harvest; Number of hands per bunch; Leaves at harvest; Banana streak virus.

Data is available and computerized.

**Protocol filename:** Nt\_Protocol\_CavendishEvaluation\_AK6.doc



## **R7529 (Banana BSV Project) – PROTOCOL JK1**

**TITLE:** Natural field spread of BSV on-station and on-farm

**Scientists:** Kubiriba J., Kenyon, L. Chancellor, T.C.B., Tushemereirwe, W.K.

**Activity Leader:** Kubiriba, J.

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** Natural Resources Institute

**Start and end dates:** 2000-2003

### **Background**

Transmission of BSV by mealybugs has only been reported under laboratory and screenhouse conditions ( Jones and Lockhart, 1993; Su, 1998; Kubiriba *et al.*, 2001). BSV – infected bananas were clustered in the farmers’ fields in Uganda and infection of plants reduced away from infection foci (Kubiriba *et al.*, 2001). This suggested a likely involvement of a slow moving vector in BSV spread. The main objective was therefore to study the spread dynamics of BSV under field conditions.

### **Objective:**

The study of the spread dynamics of BSV under field conditions on-station and on-farm.

### **Materials and methods**

Location: Mbarara, Kawanda, Ntungamo and Rakai

Choice of sites: Mbarara and Kawanda were chosen because they were on station and there were no problems of introduced infection from other sites and Williams could be used without any hinderance. On farmers’ fields (Ntungamo and Rakai), Williams was only used in small plots, while Kisansa (more accepted by farmers) was used in bigger plots. Ntungamo and Rakai have high BSV infection.

Participating farmers: See Table 1.

Planting date: See Table 1.

Cultivars: Williams (AAA) and Kisansa (AAA-EA).

Layout:

*(a) Kawanda and Mbarara on-station trials:*

A square block of banana plantation was set up of 20 plants by 20 plants making a total of 400 plants at each site for the on-station spread trials. In the middle of the block, 16 infected Mbuzirume were planted surrounded by virus indexed cv. “Williams” (Figure 1).



(b) *Small-spread trials at Rakai and Ntungamo:*

Small blocks of 4 plants x 4 plants of Williams were planted in 4 severely infected farms in Rakai and another 4 in Ntungamo.

(c) *Other spread trials:*

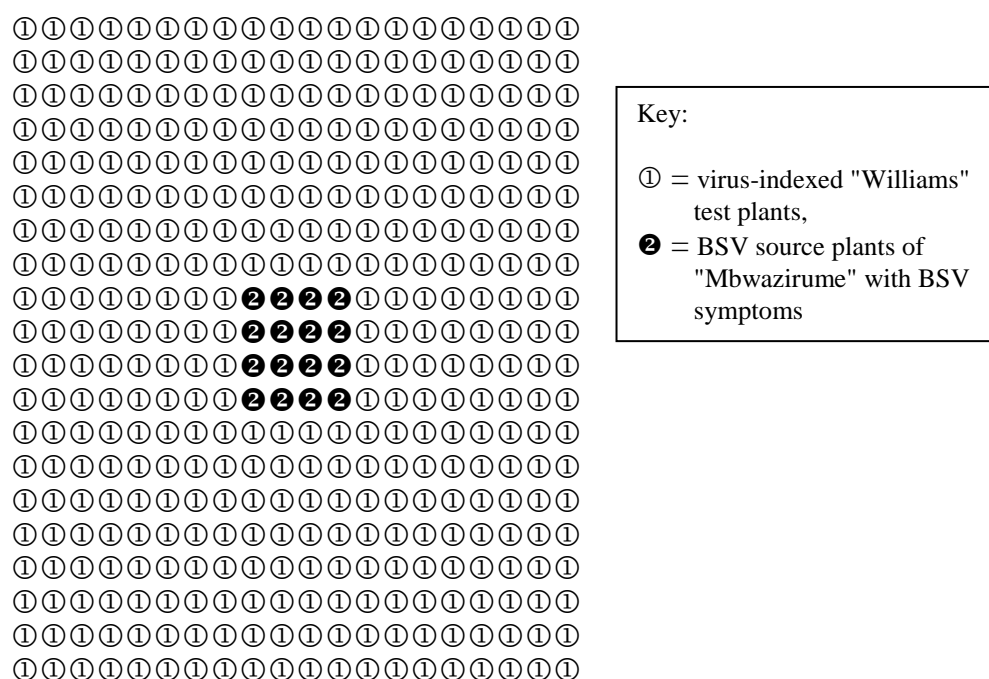
Further spread trials were established with Kisansa in Rakai (23 plants x 23 plants) and another in Ntungamo (12 plants x 12 plants) in the middle of severely infected fields (Table 1).

Management of the trial: Regular weeding and pruning

**Table 1. Location of spread trials and their planting date**

| Site               | Farmer      | Planting date                          | Size (row plants × column plants) |
|--------------------|-------------|--|-----------------------------------|
| Rakai -Nabigasa    | Sekyondwa V | May 2001                               | 4 x 4                             |
| Rakai-Nabigasa     | Muyonga     | May 2001                               | 4 x 4                             |
| Rakai-Nabigasa     | Salongo     | May 2001                               | 4 x 4                             |
| Rakai-Nabigasa     | Kawalabu    | May 2001                               | 4 x 4                             |
| Rakai-Nabigasa     | Sekyondwa   | September 1998                         | 23 x 23                           |
| Ntungamo-Kyangara  | Rwamafa     | May 2001                               | 4 x 4                             |
| Ntungamo- Kyangara | Tumusiime   | May 2001                               | 4 x 4                             |
| Ntungamo- Kyangara | Kyebitaama  | May 2001                               | 4 x 4                             |
| Ntungamo- Kyangara | Katureebe   | May 2001                               | 4 x 4                             |
| Ntungamo- Kyangara | Rwamafa     | April 2002, some replaced in Sept 2002 | 12 x 12                           |
| Kawanda            | On-station  | October 2000                           | 20 x 20                           |
| Mbarara Stock Farm | On-station  | October 2000                           | 20 x 20                           |

**Figure 1. Diagrammatic representation of the layout of the BSV spread trials at Kawanda and Mbarara**





#### Data collection:

- **BSV disease assessment**

Each data plant was assessed for noticeable foliar symptoms on individual leaves, i.e., golden yellow chlorotic streaks.

- (i) Incidence

The number of plants with BSV symptoms divided by the total number of plants in the quadrants.

- (ii) Severity

To quantify BSV symptom severity, individual leaves are being scored monthly based on a scoring system of a 0-3 scale (Dahal *et al.*, 1998b), where:

0 = no visible symptoms;

1 = less than 10% of leaf lamina has streaks or chlorotic flecks;

2 = Streaks or chlorotic flecks are present on 10-50% of leaf lamina; 3 = Streaks or chlorotic flecks cover more than 50% of leaf lamina.

The disease severity index of infected plants is calculated as follows:








**Disease severity index (SSI) = [0(a) + 1(b) + 2(c) + 3(d)]/n;**

Where, a, b, c, and d are number of leaves with scores 0, 1, 2 and 3, respectively, and n is the number of leaves on the plant.

- mealybug abundance (number of colonies per plant on the pseudostem of each of the marked plants from ground level to about 2 metres above ground.);
- distance moved by mealybugs was estimated by SADIE PC programme (Perry *et al.*, 1996).
- mealybug incidence (proportion of plants infested with mealybugs);

Data status: Most of it entered in a spread sheet and reported in the Technical report already with Lawrence

#### Data filenames:

| Name ▲   | Size     | Type                      | Modified         |
|--|----------|---------------------------|------------------|
|  K_Environ_Interaction.xls  | 107 KB   | Microsoft Excel Worksh... | 12/02/2004 12:48 |
|  K_SPREAD_BSV.xls           | 16 KB    | Microsoft Excel Worksh... | 10/02/2004 10:10 |
|  K_spread_MEALY.xls         | 508 KB   | Microsoft Excel Worksh... | 10/02/2004 10:11 |
|  Mb_spread_MEALY.xls        | 419 KB   | Microsoft Excel Worksh... | 10/02/2004 11:08 |
|  Nt_spread_Small.xls        | 499 KB   | Microsoft Excel Worksh... | 12/02/2004 11:46 |
|  R_spread_Small.xls         | 795 KB   | Microsoft Excel Worksh... | 26/08/2003 15:57 |
|  R_spread_Update AAA-EA.xls | 3,436 KB | Microsoft Excel Worksh... | 28/08/2003 11:43 |

**Protocol filename:** Protocol\_Spread\_JK1.doc



## **R7529 (Banana BSV Project) – PROTOCOL JK2**

**TITLE:** Screenhouse Transmission Experiments

**Lead Scientist:** Kubiriba J

**Other Scientists:** Kenyon, L. Chancellor, T.C.B.

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** Natural Resources Institute

**Start and end dates:** 2000-2003

### **Background:**

A number of mealybugs have been identified on bananas (Dahal, *et al.*, 1998) but only a few have been associated with BSV transmission. Those associated with BSV transmission have been obtained from hosts other than bananas. It is possible that a number of mealybugs transmit BSV and that some have not been identified under screenhouse conditions. The study was therefore undertaken to verify the role of mealybugs as BSV vectors.

### **Objectives:**

1. To identify mealybugs on bananas and construct the mealybug identification key
2. To identify BSV vectors (mealybugs collected from bananas) in screen house

### **Materials and Methods**

*For objective 1. Identification of mealybugs found on bananas*

**Sites of collection:** Ntungamo, Mbarara, Rakai, Massaka (site with high BSV infection)

**Location:** Kawanda Laboratory

**Basis:** Morphological features using a phase contrast microscope after cleaning the mealybug samples up using a method described by Chandler and Watson, (1999).

**Data collection:** Diagnostic morphological features were recorded. Mealy bug identification was based on a listing the presence/absence of a number of their characteristics. These sheets will be passed to Drucilla for entering onto a computer.

**Main output:** Identification key for mealybugs found on bananas in Africa. Published morphological features were used for those mealybugs not identified in Uganda.

**Status:** More data collected and a paper on identification key already submitted to *Journal of African Entomology* for publication.



*For objective 2. Transmission of BSV by mealybugs found on bananas under screen house conditions*

**Raising mealybug cultures:** Live mealybugs were collected from farmers' fields in ventilated bowls (lids tightly screwed on) on fresh banana pseudo-stems. Individual female mealybugs were placed on a pumpkin fruit and placed in the rearing cage in a dark shade at room temperature.

**Preparation of source plants and test plants:** One sucker of Mbwazirume showing clear BSV symptoms from the management trial at Kawanda was taken and this was multiplied by split – corm method to generate about 20 suckers for planting. They were then planted in 10 litre buckets in the screenhouse. They are sometimes cut back if they get old cut and transferred to other buckets just before use in transmission studies to allow young vigorous leaves to come up. Some farmyard manure is also applied to the buckets to keep the plants vigorous.

Cultivar Williams plants bought from South Africa were micropropagated by tissue culture. They were then hardened in the weaning sheds before transplanting them in 10 litre buckets. Transmission was done on them at about 20 cm high with 4 open young tender leaves. Williams (AAA) was used as test plants because BSV DNA sequences integrated in the Musa genome are stable and not easily excited into episomal forms that cause disease. Symptoms showing on Williams would therefore be caused by infection due to transmission by mealybugs rather than from within the plant genome.

**Site:** Two purpose built screenhouses at the IITA Namulonge – Sendusu farm.

**Treatments:** Three mealybug species (*Dysmicoccus brevipes*, *Planococcus* sp. *Pseudococcus* sp.) fed on source plants for 4 days and transferred to each of 10 test plants (Williams) and 10 controls (test plants with no mealybug instars from virus sources). Both the treated plants and the controls were sprayed after 48 hours with Chlorophyrifos 48% E.C.

**Experimental procedure:** For each experiment, more than 200 second instar mealybug nymphs from one of the pumpkin cultures were allowed to feed on young leaves of the cv. “Mbwazirume” virus source plants (contained within clip-cages) for four days. The nymphs were then transferred to 10 cv. “Williams” test plants; 20 nymphs (in a clip-cage) per plant. As the control, the original intention was to have an additional replicate with another 200+ nymphs and 10 test plants, but here the nymphs were allowed to feed for four days on non-infected leaves of cv. “Williams” prior to transfer to the test plants. Unfortunately, the latter component could not be undertaken. Instead there were 30 control plants which were not fed by mealybugs of the three species.

All plants were sprayed with Chlorophyrifos 48% E.C 24 hr after introduction of the nymphs for inoculation feeding. To avoid bias during assessment, each test and control plant was given a concealed label (a marked piece of



polythene buried in the soil of the pot) and the plants were placed in a randomised pattern in the screenhouse.

### Data Structure:

There are four treatments, i.e. three mealybug species (S1, S2, S3) and a control, and 10 plants (one plant per bucket) per treatment for the first three treatments, and 30 plants for the control, i.e. 60 plants (or buckets) which were monitored every 2 weeks for 4 months. The diagram below show the number of buckets (plants) used for each species.

| Treatment              | Buckets (plants) per treatments |   |   |   |   |   |   |   |    |    |
|------------------------|---------------------------------|---|---|---|---|---|---|---|----|----|
| Species 1 (inoculated) | 1                               | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9  | 10 |
| Species 2 (inoculated) | 1                               | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9  | 10 |
| Species 3 (inoculated) | 1                               | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9  | 10 |
| Uninoculated           | 1                               | 2 | 3 | 4 | . | . | . | . | 29 | 30 |


The experiment was run in several batches, a total of 5 batches were completed by December 2003. Some batches included 2 replications of the 60 buckets (i.e. 120 buckets), some only one replication and some could have 3 replications. Thus the number of replications per batch vary from batch to batch. All replications of a specific batch are done on the same day. The data structure is shown in the table below, where cell numbers correspond to the number of replications.

| Inoculation date | Batch Number | Number of reps |
|------------------|--------------|----------------|
| 14/07/2002       | 1            | 2              |
| 15/08/2002       | 2            | 2              |
| 05/01/2003       | 3            | 3              |
| 03/02/2003       | 4            | 3              |
| 19/02/2003       | 5            | 3              |
| 17/03/2003       | 6            | 4              |

**Data collection:** All plants were scored for incidence, i.e. number of plants with BSV symptoms divided by the total number of plants.

**Data status:** Data collection continuing at the end of December 2003 with respect to batch 6. Computerisation of the remaining 5 batches have been completed.

### Data filenames:

| Name ▲   | Size     | Type                      | Modified         |
|--|----------|---------------------------|------------------|
|  K_Screen_BSV.xls | 3,163 KB | Microsoft Excel Worksh... | 19/11/2003 15:25 |



**Data analysis objectives:**

- (a) What is the latent period for emergence of symptoms, i.e. what is the time period between sampling date (when BSV was observed) and inoculation date.
- (b) What proportion of plants have got infected by the time of first appearance of symptoms.

**Data analysis plan:**

A logistic regression analysis will be carried out (on Genstat?), adjusting for possible differences between batches and allowing for variation between treatments (inoculation levels) and species, and their interaction. The analysis should first be done for the shortest latent period under any of the treatment  $\times$  species combinations and then repeated for each monitoring point thereafter. The results should be examined before attempts are made to combine the information across the different monitoring points.

**Protocol filename:** Protocol\_Screenhouse\_JK2.doc



## **R7529 (Banana BSV Project) – PROTOCOL JK3**

**TITLE:** Symptom expression/environment interaction trial

**Scientists:** Kubiriba J., Kenyon, L. Chancellor, T.C.B., Tushemereirwe, W.K.

**Activity Leaders:** Kubiriba, J.

**Project Funding:** DFID CPP

**Research Partners:** NRI

**Start and end dates:** 2003-2004

### **Background**

Data from the spread trials revealed that there was more BSV spread in Ntungamo than in Rakai. Possible reasons could explain this situation include environmental effect on symptom expression or different BSV strains.

### **Objective:**

To determine the reasons behind the disparity in the rate of spread of BSV in Ntungamo and Rakai.

### **Materials and methods**

Location: Kawanda

Choice of sites: Kawanda was chosen because it is on station and easy to maintain.

Cultivars: Mbwaizirume

Layout:

### **BSV SYMPTOM EXPRESSION/ ENVIRONMENT INTERACTION TRIAL**

| BLOCK 1 |   |   |   |   |   | BLOCK 2 |   |   |   |   |   | BLOCK3 |   |   |   |   |   | BLOCK 4 |   |   |   |   |   |   |
|---------|---|---|---|---|---|---------|---|---|---|---|---|--------|---|---|---|---|---|---------|---|---|---|---|---|---|
| G       | G | G | G | G | G | G       | G | G | G | G | G | G      | G | G | G | G | G | G       | G | G | G | G | G |   |
| G       | 3 | 3 | 3 | 3 | 3 | G       | 4 | 4 | 4 | 4 | 4 | G      | 3 | 3 | 3 | 3 | 3 | G       | 1 | 1 | 1 | 1 | 1 | G |
| G       | 2 | 2 | 2 | 2 | 2 | G       | 2 | 2 | 2 | 2 | 2 | G      | 1 | 1 | 1 | 1 | 1 | G       | 4 | 4 | 4 | 4 | 4 | G |
| G       | 1 | 1 | 1 | 1 | 1 | G       | 3 | 3 | 3 | 3 | 3 | G      | 2 | 2 | 2 | 2 | 2 | G       | 2 | 2 | 2 | 2 | 2 | G |
| G       | 4 | 4 | 4 | 4 | 4 | G       | 1 | 1 | 1 | 1 | 1 | G      | 4 | 4 | 4 | 4 | 4 | G       | 3 | 3 | 3 | 3 | 3 | G |
| G       | G | G | G | G | G | G       | G | G | G | G | G | G      | G | G | G | G | G | G       | G | G | G | G | G | G |

G Guard rows ( Williams)



- 1 Ntungamo symptomatic Mbwarzirume ( Severe chlorotic/ necrotic streaking )
  - 2 Rakai symptomatic Mbwarzirume ( Severe candle stick/ top die back/ chlorotic/necrotic streaking)
  - 3 Kawanda symptomatic Mbwarzirume ( Severe chlorotic/ necrotic streaking )
  - 4 Kawanda asymptomatic Mbwarzirume
- REPS: 4; TRTS: 4; DESIGN:CRBD; SPACING: 3m x 3m: Planted 30 May 2001,

Infected Mbwarzirume plants material were obtained from Ntungamo, Rakai and Kawanda as a control, Mbwarzirume not showing symptoms were included and plant in a completely randomised design as above.

Management of the trial: Regular weeding and pruning

Data collection:

- **BSV disease assessment**

Different BSV symptoms were scored for presence (1) and absence (0). Each data plant was also assessed for noticeable foliar symptoms on individual leaves, i.e., golden yellow chlorotic streaks.

- (i) Incidence

The number of plants with BSV symptoms divided by the total number of plants in the quadrants.

- (iii) Severity

To quantify BSV symptom severity, individual leaves are being scored monthly based on a scoring system of a 0-3 scale (Dahal *et al.*, 1998b), where:

0 = no visible symptoms;

1 = less than 10% of leaf lamina has streaks or chlorotic flecks;

2 = Streaks or chlorotic flecks are present on 10-50% of leaf lamina; 3 = Streaks or chlorotic flecks cover more than 50% of leaf lamina.


The disease severity index of infected plants is calculated as follows:

**Disease severity index (SSI) = [0(a) + 1(b) + 2(c) + 3(d)]/n;**

Where, a, b, c, and d are number of leaves with scores 0, 1, 2 and 3, respectively, and n is the number of leaves on the plant.

Data status:

Available in directory \BSV(R7529)\Epidemiology\_JK\Spread

| Name ▲  | Size   | Type                   | Date Modified    |
|---|--------|------------------------|------------------|
|  K_Environ_Interaction.xls | 107 KB | Microsoft Excel Wor... | 12/02/2004 09:48 |

**Protocol filename:** Protocol\_Environment\_Interaction\_JK3.doc



## **R7529 (Banana BSV Project) - PROTOCOL CM1**

**The effect of climate and crop management on BSV disease and its effect on crop performance.**

**Lead Scientists:** Murekezi, C. and Wheeler, T. R.  
**Activity Leader:** Murekezi, C.  
**Project Funding:** DFID Crop Protection Programme  
**Research partners:** Natural Resources Institute and University of Reading  
**Start and end dates:** 2000 – 2003

### **Background**

Banana streak (BSV) virus disease is an important banana constraint in Uganda. BSV disease expression and therefore, its effect on bananas, are influenced by growth conditions. Air temperatures are observed to influence disease symptom expression. Preliminary reports indicate that crop management also affects BSV disease expression. There is need for empirical data on the effect of climate on disease and whether good management alleviates disease effects restoring yields to near normal.

### **Objective**

Assess the effect of crop management regime and climate on BSV incidence, severity and crop performance.

### **Materials and Methods**

*Location(s):* (i) Kawanda Agricultural Research Institute, Kampala, Central Uganda.  
(ii) Mbarara Stock Farm, Mbarara, Southern western Uganda, zone reported to have high BSV incidence (Tushemereirwe *et al*, 1996).

*Planting date:* (i) Kawanda – October 2000  
(ii) Mbarara – November 2000

### **Experimental Design:**

Two main plots and three sub-plots replicated four times. The main plot factor is crop management regime and sub-plot factor is cultivar. The main plot factor levels are optimal and minimal crop management. The design has three subplots. In the original design, 3 banana types were randomly assigned to sub plots - Cavendish, cav. Mbwazirume. Cav. Mbwazirume was divided into two based on BSV status, i.e., Mbwazirume BSV Elisa positive and Mbwazirume BSV Elisa negative. Elisa tests, though, were unreliable and plants with and without BSV symptoms were observed in plots of either BSV status. Therefore, the two plots of Mbwazirume are now considered as repeats of the same cultivar. Each sub-plot has 20 measurable plants excluded guard rows.

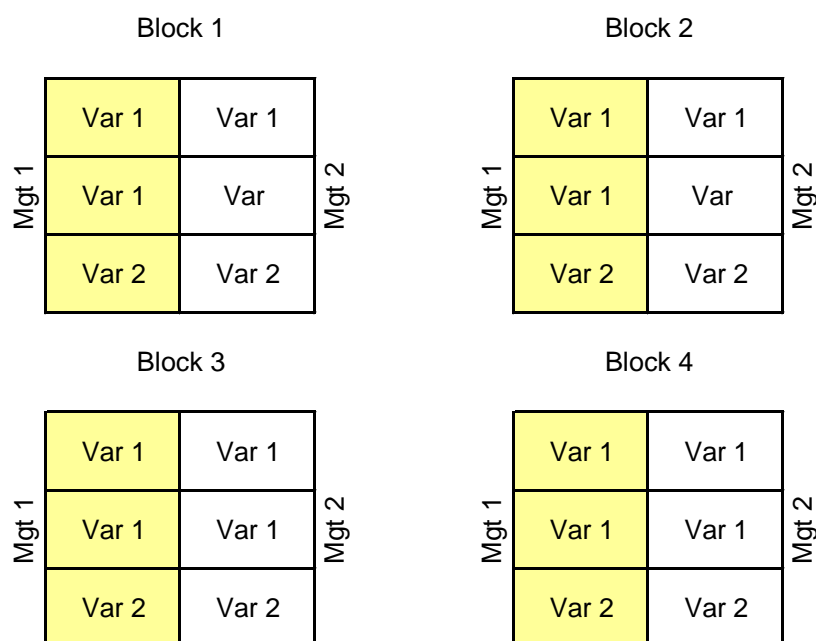


*Cultivars:* Cavendish ‘Willams’ – exotic dessert banana.  
Mbwazirume – East African Highland cooking banana.

*Crop management:*

- (i) **Optimal management:** application of mulch (10 cm thickness) and fertilisers (150 kg N, 25 kg P and 200 kg K ha<sup>-1</sup> yr<sup>-1</sup>; McIntyre, per. comm.), and routine weeding, pruning and crop sanitation.
- (ii) **Minimal management:** no mulch or fertiliser, but had 2 episodes of weeding, pruning and crop sanitation during a single crop cycle.

**Figure 1: Field plan (unrandomised): Mgt1 = optimal management, Mgt2 = minimal management, Var 1= Mbwazirume and Var 2= Cavendish.**



## Data collection:

### *Climatic data*

- (i) Air temperature, wind speed, relative humidity and incoming solar radiation are sampled at 3 m above ground and recorded hourly with a CR10 datalogger (Campbell Scientific, Pullman, WA) at each experimental site.
- (ii) Daily air temperature and relative humidity are also recorded using Tinytag data loggers (Gemini data loggers U.K. Ltd) placed in plantations.

### *Soil*

- (i) Soil temperature are also being recorded by Tinytag data loggers (Gemini data loggers U.K. Ltd) using sensors at a depth of 10 cm placed in mulched and unmulched plots.
- (ii) Profile soil water is also being measured in plots with a neutron probe (Institute of Hydrology, Oxfordshire, U.K.) at Kawanda. Measurements began March 2002. Two access tubes were installed 3 m apart mid way in each plot. Soil moisture is measured at the surface 0.3 m of profile and every 0.2 m thereafter to a depth of 1.8 m.



Measurements were made beginning 07.30 h on each measurement day. Profile soil water was measured weekly.

- (iii) Top and sub-soils will be sampled for baseline measurements. Top soil sample alone collected after one year and at the end of the experiments for the analysis of N, P, K, Ca and Mg.

### ***Crop growth***

For each these individual plants, growth will also be assessed in terms of plant height at flowering, girth (circumference of the pseudostem) at 1 m from the base of the pseudostem and total number of visible leaves.

### ***Crop development***

- (i) The leaf emergence rate (LER) of individual plants are being monitored and recorded at monthly intervals from the 1<sup>st</sup> ratoon crop onwards. At the end of each month, the mid-rib of the youngest fully emerged leaf is painted to identify it. Monthly leaf emergence rate is the number of fully opened leaves between two paintings.
- (ii) Flower emergence date for each plant, which is when the top female hand is first visible on the developing bunch, is being monitored and recorded.
- (iii) Days of bunch development (flower emergence to bunch maturity) are also recorded.

### ***Disease assessment***

To quantify BSV symptom severity, individual leaves are being scored monthly based on a scoring system of a 0-3 scale (Dahal *et al.*, 1998b), where:

- 0 = no visible symptoms;
- 1 = less than 10% of leaf lamina has streaks or chlorotic flecks;
- 2 = Streaks or chlorotic flecks are present on 10-50% of leaf lamina;
- 3 = Streaks or chlorotic flecks cover more than 50% of leaf lamina.

The disease severity index of infected plants is calculated as follows:

$$\text{Disease severity index (SSI)} = [0(a) + 1(b) + 2(c) + 3(d)]/n;$$

Where, a, b, c, and d are number of leaves with scores 0, 1, 2 and 3, respectively, and n is the number of leaves on the plant.

### ***Yield***

When the bunch of each plant reaches maturity, the following are recorded:

- (i) Number of hands per bunch;
- (ii) Bunch weight (kg).













### **Data status (Computerised):**

- Kawanda: Parent crop and 1<sup>st</sup> ratoon crop for all
- Mbarara: Parent crop for all












**Data filenames:** Given below.

Kawanda:

| Name ▲  | Size   | Type                      | Modified         |
|---|--------|---------------------------|------------------|
|  K_CISt_BulkDen_1stYear.xls    | 23 KB  | Microsoft Excel Worksh... | 18/11/2003 12:34 |
|  K_CISt_BulkDen_baseline.xls   | 256 KB | Microsoft Excel Worksh... | 19/01/2004 12:08 |
|  K_CISt_Gr&Yld_climate00.xls   | 55 KB  | Microsoft Excel Worksh... | 21/01/2004 10:27 |
|  K_CISt_Gr&Yld_climate01.xls   | 54 KB  | Microsoft Excel Worksh... | 21/01/2004 10:27 |
|  K_CISt_Gr&Yld_climate02.xls   | 52 KB  | Microsoft Excel Worksh... | 21/01/2004 10:29 |
|  K_CISt_Gr&Yld_parent.xls      | 447 KB | Microsoft Excel Worksh... | 21/01/2004 10:37 |
|  K_CISt_PlantNut_1stRatoon.xls | 15 KB  | Microsoft Excel Worksh... | 18/11/2003 12:34 |
|  K_CISt_PlantNut_parent.xls    | 17 KB  | Microsoft Excel Worksh... | 18/11/2003 12:34 |
|  K_CISt_SoilNut_1stYear.xls    | 20 KB  | Microsoft Excel Worksh... | 21/01/2004 10:36 |
|  K_CISt_SoilNut_baseline.xls   | 18 KB  | Microsoft Excel Worksh... | 21/01/2004 10:33 |
|  K_CIStr_Gr&Yld_1st ratoon.xls | 513 KB | Microsoft Excel Worksh... | 21/01/2004 10:24 |
|  kawdataloggers.xls            | 20 KB  | Microsoft Excel Worksh... | 19/01/2004 14:02 |

Mbarara:

| Name ▲  | Size   | Type                      | Modified         |
|---|--------|---------------------------|------------------|
|  M_C&St_BulkDen_1stYear.xls    | 29 KB  | Microsoft Excel Worksh... | 22/01/2004 11:13 |
|  M_C&St_PlantNut_1stRatoon.xls | 25 KB  | Microsoft Excel Worksh... | 22/01/2004 10:53 |
|  M_C&St_SoilNut_1stYear.xls    | 20 KB  | Microsoft Excel Worksh... | 22/01/2004 11:04 |
|  M_C&St_SoilNut_baseline.xls   | 18 KB  | Microsoft Excel Worksh... | 22/01/2004 08:57 |
|  M_CISt_Gr&Yld_1stRatoon.xls   | 285 KB | Microsoft Excel Worksh... | 22/01/2004 07:38 |
|  M_CISt_Gr&Yld_climate02.xls   | 55 KB  | Microsoft Excel Worksh... | 22/01/2004 14:42 |
|  M_CISt_Gr&Yld_climate03.xls   | 47 KB  | Microsoft Excel Worksh... | 22/01/2004 12:37 |
|  M_CISt_Gr&Yld_dataloggers.xls | 26 KB  | Microsoft Excel Worksh... | 22/01/2004 12:32 |
|  M_CISt_Gr&Yld_parent.xls      | 193 KB | Microsoft Excel Worksh... | 22/01/2004 07:40 |

**Protocol filename:** Protocol\_CLST\_YldLoss\_CM1.doc



## **R7529 (Banana BSV Project) - PROTOCOL CM2**

**TITLE:** The effect of BSV disease on banana physiology.

**Lead Scientists:** Murekezi, C., Kubiriba, J., Wheeler, T. R and Kenyon, L.

**Activity Leader:** Murekezi, C.

**Project Funding:** DFID Crop Protection Programme

**Research partners:** Natural Resources Institute and University of Reading

**Start and end dates:** 2000 – 2003

### **Background**

Banana is a large crop and destructive harvests to quantify the effects of BSV on growth and yield is potentially problematic. Non destructive assessments of crop growth, therefore, are being used in this study to quantify the effect BSV and crop treatments. Light capture and photosynthesis are being used.

### **Objective**

To quantify the effect of BSV on growth and yield of bananas.

### **Materials and Methods**

*Location:* Kawanda

*Trial set up date:* Kawanda – October 2000

#### *Experimental Design:*

Two main plots and two sub-plots replicated four times. The main plot factor is crop management regime and sub-plot factor is cultivar. The main plot factor levels are optimal and minimal crop management. The design has two subplots. Two banana cultivars were randomly assigned to sub plots – Cavendish and cav. Mbwarzirume. Each sub-plot has 20 measurable plants excluded guard rows.

*Cultivars:*

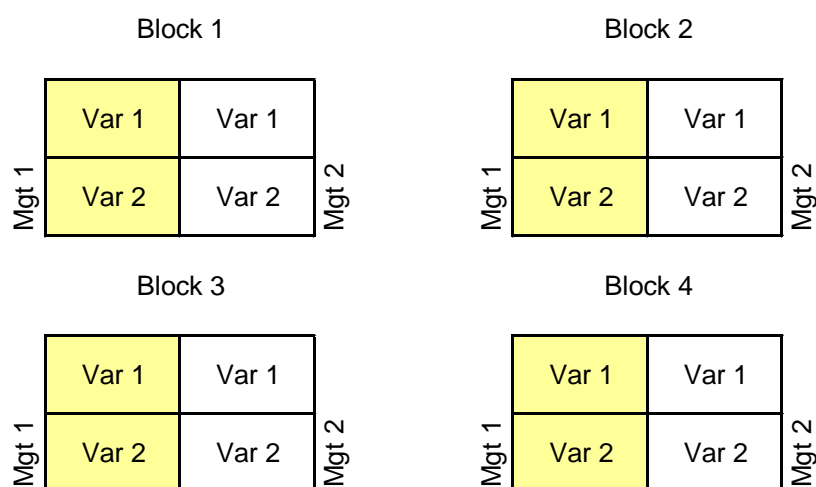
- (i) Cavendish ‘Williams’ – exotic dessert banana.
- (ii) Mbwarzirume – East African Highland cooking banana.

#### *Crop management:*

- (i) **Optimal management:** application of mulch (10 cm thickness) and fertilisers (150 kg N, 25 kg P and 200 kg K ha<sup>-1</sup> yr<sup>-1</sup>; McIntyre, per. comm.), and routine weeding, pruning and crop sanitation.
- (ii) **Minimal management:** no mulch or fertiliser, but had 2 episodes of weeding, pruning and crop sanitation during a single crop cycle.



**Figure 1: Field design, Mgt1 = optimal management, Mgt2 = minimal management, Var 1= Mbwarzirume and Var 2+ Cavendish.**



## Data collection:

### *Climatic data*

- (i) Air temperature, wind speed, relative humidity and incoming solar radiation are sampled at 3 m above ground and recorded hourly with a CR10 datalogger (Campbell Scientific, Pullman, WA) at each experimental site.
- (ii) Daily air temperature and relative humidity are also recorded using Tinytag data loggers (Gemini data loggers U.K. Ltd) placed in plantations.

### *Soil*

- (i) Profile soil water is also being measured in plots with a neutron probe (Institute of Hydrology, Oxfordshire, U.K.) at Kawanda. Measurements began March 2002. Two access tubes were installed 3 m apart mid way in each plot. Soil moisture is measured at the surface 0.3 m of profile and every 0.2 m thereafter to a depth of 1.8 m. Measurements were made beginning 07.30 h on each measurement day. Profile soil water was measured weekly.
- (ii) Top and sub-soils will be sampled for baseline measurements. Top soil sample alone collected after one year and at the end of the experiments for the analysis of N, P, K, Ca and Mg.

### *Crop growth*

For each of these individual plants, growth will also be assessed in terms of plant height at flowering, girth (circumference of the pseudostem) at 1 m from the base of the pseudostem and total number of visible leaves.

### *Crop development*

- (i) Flower emergence date for each plant, which is when the top female hand is first visible on the developing bunch, is being monitored and recorded.
- (ii) Days of bunch development (flower emergence to bunch maturity) are also recorded.



### **Disease assessment**

To quantify BSV symptom severity, individual leaves are being scored monthly based on a scoring system of a 0-3 scale (Dahal *et al.*, 1998b), where:

- 0 = no visible symptoms;
- 1 = less than 10% of leaf lamina has streaks or chlorotic flecks;
- 2 = Streaks or chlorotic flecks are present on 10-50% of leaf lamina;
- 3 = Streaks or chlorotic flecks cover more than 50% of leaf lamina.

The disease severity index of infected plants is calculated as follows:

$$\text{Disease severity index (SSI)} = [0(a) + 1(b) + 2(c) + 3(d)]/n;$$

Where, a, b, c, and d are number of leaves with scores 0, 1, 2 and 3, respectively, and n is the number of leaves on the plant.

### **Physiology data**

- (i) Destructive sampling was done in December 2001, March 2002, May 2002 and July 2000 for the 1<sup>st</sup> ratoon crop cycle to determine dry matter increases. Two plants (on with symptoms and one without) will be randomly selected in each sub-plot will be harvested into leaves, pseudostem and corm. Thereafter, the plant parts will be oven dried at 70°C for 48 hours, giving dry weight.
- (ii) Light interception was measured for the destructively sampled plants using a Sunflecks Ceptometer. Incident light above the banana canopy was measured using sensors in an open area next to the banana experimental field. Light incident at the base of each banana plant canopy will be an average of several readings measured by sensors at several locations around the plant.
- (iii) Photosynthesis (Tim Wheeler)

### **Yield**

When the bunch of each plant reaches maturity, the following are recorded:







- (i) Number of hands per bunch;
- (ii) Bunch weight.

### **Data status (Computerized):**

Crop growth, disease assessments and yield – parent crop

Destructive and light interception – 1<sup>st</sup> ratoon crop.

### **Data file names:**

| Name ▲  | Size   | Type                      | Modified         |
|---|--------|---------------------------|------------------|
|  K_Phys_BulkDen_1stYear.xls  | 25 KB  | Microsoft Excel Worksh... | 22/01/2004 13:16 |
|  K_Phys_BulkDen_baseline.xls | 22 KB  | Microsoft Excel Worksh... | 22/01/2004 13:14 |
|  K_Phys_Gr&Yld_1stRatoon.xls | 113 KB | Microsoft Excel Worksh... | 22/01/2004 13:11 |
|  K_Phys_Gr&Yld_parent.xls    | 253 KB | Microsoft Excel Worksh... | 22/01/2004 16:11 |
|  K_Phys_SoilNut_1stYear.xls  | 19 KB  | Microsoft Excel Worksh... | 22/01/2004 13:13 |
|  K_Phys_SoilNut_baseline.xls | 18 KB  | Microsoft Excel Worksh... | 22/01/2004 13:12 |

**Protocol filename:** Protocol\_Phys\_CM2.doc



## **R7529 (Banana BSV Project) - PROTOCOL CM&JK.doc**

**TITLE:** **EFFECT OF FARMER CULTURAL PRACTICES ON BANANA STREAK VIRUS (BSV) EXPRESSION.**

**Lead Scientists:** Murekezi, C., Kubiriba, J., Wheeler, T. R and Kenyon, L.

**Activity Leaders:** Murekezi, C., Kubiriba, J.

**Project Funding:** DFID – Crop Protection Programme

**Research partners:** Natural Resources Institute and University of Reading

**Start and end dates:** 2000 – 2003

### **Background**

Areas producing bananas in Uganda have been categorized into three zones. These included areas of extreme production decline (most areas of Central Uganda), those of relatively high production (Mbarara and Bushenyi) and those of intermediate banana production levels (Masaka, Rakai and Ntungamo). In the intermediate production zone, banana streak virus (BSV) is a prominent banana constraint. It is reported that improved crop management ameliorates the effects of BSV. Cultural practices are most commonly used by farmers in the management of banana constraints. These practices are popular because they require cheap and locally available on/off farm resources. A study was initiated, therefore, to ascertain the potential of farmers' cultural practices in managing BSV.

### **Objective**

The specific objective of the study was to investigate the response of the East African Highland banana to BSV in relation to different farmers' cultural management practices by monitoring the effect of the practices on mealybug abundance and incidence, BSV incidence and symptom expression, and banana growth characteristics and yield.

### **Materials and Methods**

*Location:* Kikoni Parish, Ntungamo district in south western Uganda

*Trial set up date:* Ntungamo – August 2001

#### *Preliminary survey*

The study was preceded by a survey conducted in February 2001 in 6 villages in Ntungamo district. In the survey, 60 farmers' fields were randomly selected across the villages of Mutanoga, Muyumbu, Kyangara, Kalegeya, Kamunyiga and Musaana. During the survey, the main farmer cultural practices were noted and the status of BSV on these farms was assessed.

Seven cultural practices were found to be commonly used by farms in the management of bananas. They were (1) provision of soil and water conservation structures (water bunds), (2) application of an organic mulch, (3) regular desuckering, (4) regular detrashing, (5) manure application, (6) regular weeding and (7) cropping pattern (sole cropping of banana and



intercropping banana with beans or other intercrops). Apart from cropping patterns, the other cultural practices are being carried out by farmers to manage banana plantations. Initially management practices were classified as in Table 1 by giving more weight to management practices that, based on the investigators' experience, had a direct impact on both BSV expression and mealybug population.

The total weight of the cultural practices carried out on a field was the sum of the weights of the individual practices. This total weighting was used to determine the overall management status of a farm being assessed. The overall management categories were as follows: Low  $\leq 7$ , Moderate 8-15 and Intensive  $\geq 16$ .

### **Farmer selection:**

30 farms where BSV was present were selected to participate in the study. This selection included 10 farms where the overall management was intensive, 10 where the management was moderate and 10 where the management was low.

### **Plant identification:**

In each of the 30 farms four quadrants measuring 15 x 15m were assigned in the banana fields. Ten plants were then selected and marked with paint (regularly renewed) in each quadrant making a total of 40 plants per farm that then comprised the data plants. Data collection commenced in August 2001.

**Table 1. Cultural practices and the assigned weightings**

| Cultural practice                                       | Weight    |
|---|-----------|
| 1. Soil and water conservation structures (water bunds) | 6         |
| 2. Application of mulch                                 | 5         |
| 3. Desuckering and Detrashing                           | 4         |
| 4. Manure/soil inputs                                   | 3         |
| 5. Weeding  | 2         |
| 6. No Intercropping                                     | 1         |
| (Maximum score)   | <b>21</b> |

### **Data collection**

*Frequency of visits to each farm:* Once a month and some times bi-monthly.

#### *Measurements taken:*

- **Disease assessment**

Each data plant was assessed for noticeable foliar symptoms on individual leaves, i.e., golden yellow chlorotic streaks.

- (i) Incidence

The number of plants with BSV symptoms divided by the total number of plants in the quadrants.

- (iv) Severity

To quantify BSV symptom severity, individual leaves are being scored monthly based on a scoring system of a 0-3 scale (Dahal *et al.*, 1998b), where:

0 = no visible symptoms;



- 1 = less than 10% of leaf lamina has streaks or chlorotic flecks;
- 2 = Streaks or chlorotic flecks are present on 10-50% of leaf lamina; 3
- = Streaks or chlorotic flecks cover more than 50% of leaf lamina.

**The disease severity index of infected plants is calculated as follows:**

Disease severity index (SSI) =  $[0(a) + 1(b) + 2(c) + 3(d)]/n$ ;

where, a, b, c, and d are number of leaves with scores 0, 1, 2 and 3, respectively, and n is the number of leaves on the plant.

- mealybug abundance (number of colonies per plant on the pseudostem of each of the marked plants from ground level to about 2 metres above ground.);
- mealybug incidence (proportion of plants infested with mealybugs);
- plant height (measured from the base of pseudostem to the emerging inflorescence);
- noticeable foliar symptoms on individual leaves per plant, i.e., golden yellow chlorotic streaks.
- pseudostem circumference (girth), measured at a height of 100 cm from the base of the plant at flowering;
- bunch weights (estimated within 3 weeks of bunch maturity).
- soils data (year 2), i.e. pH, %OM, %N, available P(ppm), exchangeable K, Ca, Mg, (in milli equivalents per 100 gms of soil), %sand, %clay, %silt.
- Climate parameters (years 1 and 2), e.g. mean, minimum, maximum air temperature, mean RH, and total rainfall.

In addition, farmer cultural practices were recorded, by assessing each marked plant, at each data collection time point as described below.

1. Soil and water conservation structures (water bunds):

(0) Minimum 0 –1 water bunds per plantation (gentle/no slope); 0-2 bunds (steep slope)

(1) Adequate – more than minimal above

2. Mulch application<sup>1</sup>:

(0) Absent - no mulch evident in the banana field or does not satisfy condition below.

(1) Present - mulch cover of > 5 cm for a period  $\geq$  4 months in a year

3. Desuckering (removal of excess suckers):

(0) Minimal –  $\geq$  4 plants per mat for > 5 months a year

(1) Adequate -  $\leq$  3 plants per mat for > 5 months a year

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<sup>1</sup> Recorded as present/absent at sampling point, but summarised per year as high/low according to definition given.



4. Detrashing:

- (0) Minimal – dead leaves and sheaths present on plants for > 5 months a year
- (1) Adequate – dead leaves and sheath present on plants < 5 months

5. Manure:

- (0) Minimal (little)– no/trace amounts applied in the banana field
- (1) Adequate (some) – more than trace amounts of manure applied in the field

6. Weeding:

- (0) Poor – many weeds in plots for > 5 months a year
- (1) Adequate/good – no/few weeds in banana plots for > 5 months a year

7. Cropping pattern (Use of intercrops):

- (0) Sole cropping – no systematic intercrops in the banana field
- (1) Intercropping – systematic intercrops in banana field

**Data status:** (Computerized):

All data from August 2001 – January 2003.

**Data analysis**

The effects of farmer cultural practices on mealybug abundance, proportion of plants infested with mealybugs, BSV incidence, BSV severity, growth (plant height and girth) and bunch weights were determined through data analysis using the general and generalized linear model procedures in SAS (SAS Inc., 1997). Data on mealybug abundance and BSV severity was analyzed using a repeated measure approach in general linear model procedure (GLM). Data on proportion of plants, mealybugs and BSV incidence was analyzed as composite data sets. The proportions of mealybugs and BSV incidence were analyzed as averages since they did not alter with time. Proportion of plants infested with mealybugs and BSV incidence per farm per month was analysed by Genmod procedure since the error terms were best described by binomial distribution with logit link function for the individual practices and those for over all management by Poisson distribution with log link function.



## **R7972 (Banana Weevils Project) – PROTOCOL ME1**

**TITLE:** EFFECT OF SOIL AMENDMENTS IN THE DELIVERY SYSTEM OF *BEAUVERIA BASSIANA* FOR CONTROL OF THE BANANA WEEVIL

**Scientists:** Dr. C.M. Nankinga (Principal Investigator) and Mr. Evarist Magara (M.Sc. student).

**Activity Leader:** Mr. Evarist Magara

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** University of Reading, IITA

**Start and end dates:** 2001 to March 2004

### **Research Background:**

Bananas (*Musa* spp.) are an important food and cash crop in Uganda, and in other parts of the world (Karamura, 1992, Gold and Rubaihayo, 1993). The banana weevil, *Cosmopolites sordidus* has been recognised as one of the major constraints to banana production. Little control of the banana weevil has been achieved by use of current cultural, biological and chemical strategies. Recent studies (Kaaya *et al.*, 1993, Nankinga, 1994, 1999, Traore, 1995, and Godonou, 1999) indicate that the entomopathogenic fungus, *Beauveria bassiana* has a high potential as a biological control agent for the weevil in Africa. However, the biotic and abiotic factors that may influence the efficacy and persistence of this fungus under field conditions are not yet fully evaluated.

Therefore, this study aims at evaluating the efficacy and persistence of various *B. bassiana* formulations under laboratory conditions and evaluating the most effective formulation under pot and field conditions<sup>1</sup>. Five different levels of soil amendments in form of decomposed cow dung, coffee husks and an optimum level of artificial fertilizers will be evaluated. Soil characteristics in the different amendments will be monitored and related to the fungal efficacy and persistence. The study will be useful in establishing some of the vital field conditions required for effective use or non-use of *B. bassiana* for the biological control of the banana weevil.

**Key words:** *B. bassiana*, *C. sordidus*, efficacy, persistence, soil amendments, Bananas

**Objective:** To study the infectivity of different *B. bassiana* formulations to the banana weevil (*Cosmopolites sordidus*). More specifically

- i) To determine the amount of conidia produced from different *B. bassiana* substrates.
- ii) To evaluate the infectivity of different *B. bassiana* formulations against the banana weevil under laboratory conditions.

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<sup>1</sup> This protocol concerns the laboratory experiments.



## Materials and Methods:

**Location:** Banana nematology/weevil laboratory, Kawanda

### *Source of materials:*

| Material                      | Source  |
|-------------------------------|---|
| Cracked maize and maize bran. | Kawempe maize mill.   |
| Bagasse                       | Lugazi sugar works  |
| “Machicha”                    | Kawanda malwa (local brew) joint  |
| Cotton husks                  | Kawempe ginnery   |
| <i>B. bassiana</i> inoculum   | lab. reserved conidia which is continuously recultured, and kept in the fridge at 4°C.                        |
| Banana weevils                | parent stock collected from Masaka District, then reared in metallic drums in a shade outside the laboratory. |
| Spent yeast                   | Uganda Breweries.   |
| Sucrose(sugar)                | Purchased from retail shops.  |
| Clay and loam soils           | KARI swamp and field respectively.  |

### *Preparation of experimental materials and data collection*

#### *a) B. bassiana spore (conidia) counts*

METHOD (Ref: LUBILOS 77pp)

- 1g of fungal substrate weighed into a testube.
- Mix with 100 ml of distilled water, then add 2 drops of liquid soap
- Let the solution settle for about 10 minutes.
- Shake and mix thoroughly.
- Measure out 1 ml and mix it with 9 mls of distilled water (=  $10^{-1}$  dilution).
- Using a dropper to introduce one drop into the counting chamber.
- Count the spores in the 5 diagonal big squares, in the 2 grids.
- Finally use the formula  $C = A \times 5 \times 10^4$ , where C is the concentration of spores/ml in the diluted quantity and A is the average spore counts from the 2 grids (grids1+2/2).
- The concentration of spores in the original solution before dilution;
- $S = C \times 10^n$  where n is the number of dilutions. This implies that
- $S = A \times 5 \times 10^4 \times 10^n$ , where n is the number of dilutions.

#### *b) Banana weevils rearing*

The initial batch of banana weevils were trapped from KARI and farmers' banana plantations in Masaka using split pseudo stem traps. The weevils were reared from metallic drums on fresh banana corms under a shade as described by Nankinga (1999). The adult weevils were introduced to pared banana corms to oviposit eggs for seven days and there after the banana corms were maintained in metallic drums for 60 days to allow development of eggs to adults. The drums were covered with papyrus mats to avoid desiccation.



### *c) B. bassiana culturing and formulation*

One strain of the fungus, code G41, known to have high pathogenicity to *C. sordidus*, superior growth and Sporulation was used. It was cultured in KARI insect pathology laboratory on the substrates under evaluation; cracked maize, maize bran, "machicha", cotton husks, bagasse, cotton husks + maize bran, maize bran + bagasse and bagasse + spent yeast. The substrates were cultured following the modified diphasic method described by Nankinga (1999). Where substrate mixtures were made, this was done to the ratio of 1:1 by volume.

"Machicha" is spent millet and yeast residue obtained after a local potent gin ("malwa") has been extracted. This was collected from the local drinking places, washed, dried and used for culturing the fungus. The amount of conidia produced in each gram substrate was determined using the improved Neubauer Hemacytometer counting chamber (0.100mm deep), as described in the section on spore counts.

### *d) Formulations for Laboratory bioassays*

The formulations evaluated were *B. bassiana* grown on cracked maize seed, maize bran and "machicha", applied alone or formulated with loam soil or clay soil. The formulations were chosen depending on their conidia yields (see the data). The loam soil was collected from the banana field at KARI with the physical characteristics of estimate levels of sand (52%), silts (28-50%), clay (7-28%), and high water holding capacity (23%). The clay soil used was the gray type, mined from water logged swamps, with particle size of approximately 0.002 mm. Thus, eleven (11) *B. bassiana* formulations were evaluated under laboratory conditions and these are;

- Maize bran alone, maize bran + loam soil, maize bran + clay soil
- "Machicha" ("bussa") alone, "machicha" + loam soil, "machicha" + clay soil
- Cracked maize alone, cracked maize + loam soil, cracked maize + clay soil
- Loam soil alone or clay soil alone with nothing added.

The *B. bassiana* grown on cracked maize substrate was used as the standard. 1g of this substrate was mixed with 1g of the sterile formulation (1:1 ratio). The 2g was then weighed into plastic petri- dishes and replicated 3 times. The amount of conidia in each treatment was standardized to the same level as in cracked maize. The amounts of the other substrates used depended on the amount of conidia per gram determined. They were also in the ratio of 1:1 per formulation.

### ***Key dates associated with the trial:***

(a) *B. bassiana* culturing and conidia counts: 29/11/01- 20/05/02.

(b) Laboratory tests for the different *B. bassiana* formulations: 24/05-24/06/02.

### ***Experimental treatments***

a) No. of substrates = 8 (for objective 2i above); these are; Cracked maize, Maize bran, "Machicha", Cotton husks, Bagasse, Cotton husks + maize bran, Maize bran + bagasse, Bagasse + spent yeast.

b) No. of formulations =11 (for objective 2ii above) and these are; Clay soil alone, Loam soil alone, Cracked maize+ clay, Maize bran+ clay, "Machicha"+clay, Cracked maize alone, Maize bran alone, "Machicha" alone, Maize bran +loam, Cracked maize +loam, "Machicha" + loam soil.

c) No. of replicates per formulation = 3; for each experiment.

d) No. of weevils per replicate = 10 of mixed sex (1:1ratio).



### ***Experimental design:***

Completely Randomised Design (CRD), since the laboratory area used was uniform. First the treatments were allocated to petridishes at random. An area measuring 1x1m was marked on the laboratory bench. A table of random numbers was used. The positions for placement of petridishes were marked on the bench and each petridish randomised to marked positions, using a table of random numbers.

### **Measurements:**

➤ amount of conidia per unit gram of substrate.

➤ weevil mortality in the different formulations.

The number of dead weevils were recorded at different time points i.e by observing the weevils after every 5 days for mortality, over a 30-day period. Any dead weevils were removed, and put into a moist chamber and observed for any *B. bassiana* fungal growth.

Data on each of the above activities were entered into computer Excel sheets immediately after being collected.

### **Management of the different activities:**

*B. bassiana* production and conidia counting :Magara Evarist, Hellen Pedum (technician).

*Experimental set up:* weevil collection, sexing, counting, formulation mixtures, weevil exposure to the fungus and weevil mortality records; Magara Evarist.

*Data collection:* Magara Evarist.

### **Data files:**

The data files are kept on C drive in the following computers in a folder labelled 'magara': Caroline 2 computer, Banana 101computer, Africano computer, and students computer. In addition, the raw data are kept in a laboratory book, and in a box file clearly labelled 'Magara Evarist MSc.'.

They are also available on Yusuf's computer in the file **lab\_pot\_data.xls**.

### **Plan for data analysis:**

The data from the experiment will be subjected to statistical analysis using the SAS package. Analysis of variance will be carried out to compare treatment and comparison of interest will be made using estimate statement in SAS PROC GLM.

**Data filenames:** *K\_Bb\_Formulations&SoilAmendmentsLabPot.xls*

**Protocol filename:** *Protocol\_SoilAmendments\_Lab\_ME1.doc*



## Sample data sheets

### Data sheet 1

The following is the data sheet for recording the amount of conidia from different substrates

DATE.....

| Substrate | Reps | Grid counts |   | Mean<br>(A) | Spores<br>/ml | Spores/<br>gram |
|-----------|------|-------------|---|-------------|---------------|-----------------|
|           |      | 1           | 2 |             |               |                 |
|           |      |             |   |             |               |                 |
|           |      |             |   |             |               |                 |
|           |      |             |   |             |               |                 |

### Data sheet 2

Laboratory bioassays: Weevil mortality from the different formulations

Date.....

| Formulation | REPS | WEEVIL MORTALITY (numbers) at different dates |    |    |    |    |    |                     |
|-------------|------|---|----|----|----|----|----|---------------------|
|             |      | 5   | 10 | 15 | 20 | 25 | 30 | TOTAL M<br>from B.b |
|             |      |   |    |    |    |    |    |                     |
|             |      |   |    |    |    |    |    |                     |
|             |      |   |    |    |    |    |    |                     |
|             |      |   |    |    |    |    |    |                     |
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## **R7972 (Banana Weevils Project) – PROTOCOL ME2**

**TITLE:** EFFECT OF SOIL AMENDMENTS IN THE DELIVERY SYSTEM OF *BEAUVERIA BASSIANA* FOR CONTROL OF THE BANANA WEEVIL

**Scientists:** Dr. C.M. Nankinga (Principal Investigator) and Mr. Evarist Magara (M.Sc. student).

**Activity Leader:** Mr. Evarist Magara

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** University of Reading, IITA

**Start and end dates:** 2001 to March 2004

### **Research Background:**

Bananas (*Musa* spp.) are an important food and cash crop in Uganda, and in other parts of the world (Karamura, 1992, Gold and Rubaihayo, 1993). The banana weevil, *Cosmopolites sordidus* has been recognised as one of the major constraints to banana production. Little control of the banana weevil has been achieved by use of current cultural, biological and chemical strategies. Recent studies (Kaaya *et al.*, 1993, Nankinga, 1994, 1999, Traore, 1995, and Godonou, 1999) indicate that the entomopathogenic fungus, *Beauveria bassiana* has a high potential as a biological control agent for the weevil in Africa. However, the biotic and abiotic factors that may influence the efficacy and persistence of this fungus under field conditions are not yet fully evaluated.

Therefore, this study aims at evaluating the efficacy and persistence of various *B. bassiana* formulations under laboratory conditions and evaluating the most effective formulation under pot and field conditions<sup>2</sup>. Five different levels of soil amendments in form of decomposed cow dung, coffee husks and an optimum level of artificial fertilizers will be evaluated. Soil characteristics in the different amendments will be monitored and related to the fungal efficacy and persistence. The study will be useful in establishing some of the vital field conditions required for effective use or non-use of *B. bassiana* for the biological control of the banana weevil.

**Key words:** *B. bassiana*, *C. sordidus*, efficacy, persistence, soil amendments, Bananas

### **Objective:**

To determine the effect of different levels of coffee husks, decomposed cow dung manure and artificial fertilizers on the efficacy and persistence of *B. bassiana*

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<sup>2</sup> This protocol concerns the pot experiments.



## Materials and Methods:

**Location:** In open air outside the Banana nematology/weevil laboratory, Kawanda.

### *Source of materials*

| Material                                  | Source  |
|---|---|
| Cracked maize <i>B. bassiana</i> culture. | Prepared from KARI pathology laboratory., using the materials described under lab expt. |
| Banana weevils                            | stock reared in metallic drums in a shade outside the laboratory.                       |
| Mpologoma cultivar suckers                | Bloch 10, at KARI.  |
| Decomposed cow dung                       | Farmer's compost heap at Nakyesanja, near KARI.   |
| Coffee husks                              | Matugga coffee factory, near KARI.  |
| Artificial fertilizers                    | Balton (U) Ltd, in Kampala industrial area.   |
| Soil                                      | Extension G, KARI; where the field trial is located                                     |
| Dried banana leaves mulch                 | Mpologoma cultivar in block 10.   |

### *Preparation of experimental materials and data collection*

#### *(a) Amendments:*

The amendments were taken by volume. A plastic bowl measuring 1200cm<sup>2</sup> was used as a unit of measure. The different levels were measured into 6,000cm<sup>3</sup> buckets/pots as per the required levels/ratios.

#### *(b) Banana weevils rearing*

The initial batch of banana weevils were trapped from KARI and farmers' banana plantations in Masaka using split pseudo stem traps. The weevils were reared from metallic drums on fresh banana corms under a shade as described by Nankinga (1999). The adult weevils were introduced to pared banana corms to oviposit eggs for seven days and thereafter the banana corms were maintained in metallic drums for 60 days to allow development of eggs to adults. The drums were covered with papyrus mats to avoid desiccation.

#### *(c) B. bassiana culturing*

One strain of the fungus, code G41, known to have high pathenogenicity to *C. sordidus*, superior growth and Sporulation was used. It was cultured in KARI insect pathology laboratory on cracked maize. The substrate was cultured following the modified diphasic method described by Nankinga (1999). It was then dried and packaged in 100g lots in polythene bags.

#### *d) Banana suckers and the pots:*

Clean mpologoma suckers were got from block 10, pared and planted in the pots with the amendments. Pots were first perforated at the bottom with holes (10 in each) using a hot needle. A mesh was placed on the bottom inside to limit entry and exit of weevils.

#### *e) B. bassiana and Weevils introductions:*

100g of cracked maize *B. bassiana* culture was applied around each plant in the pot. 50g of dried banana mulch was placed on top of the fungus. 10 weevils of mixed sex were released into each pot. A mesh was tied on top of each of the pots to limit weevil escape.



**Key dates associated with the trial:**

*B. bassiana* efficacy and persistence tests in different soil amendments

| Activity   | Batches/weevil releases | Dates    |
|--|-------------------------|----------|
| i) Planting in pots:   | I-III batches           | 21/07/02 |
|  | IV batch                | 27/10/02 |
| ii) <i>B.b</i> application:  | I-III batches           | 24/08/02 |
|  | IV batch                | 30/11/02 |
| iii) Weevil releases (at 30-day intervals):                                |                         |          |
|  | Batch I                 | 24/08/02 |
|  | Batch II                | 24/09/02 |
|  | Batch III               | 24/09/02 |
|  | Batch IV                | 30/02/03 |
| iv) Destructive sampling of pots and their contents ( done after 6 weeks): |                         |          |
|  | I                       | 5/10/02  |
|  | II                      | 5/11/02  |
|  | III                     | 5/12/02  |
|  | IV                      | 14/04/03 |

**Note:** The 4<sup>th</sup> batch/release was planted later, thus it has different timings from the rest.

**Experimental treatments:**

a) There were five treatments, i.e. 4 amendments: coffee husks, decomposed cow dung, artificial fertilizers (optimum) and a control, i.e. soil alone.

Coffee husks and decomposed cow dung were applied in 4 different levels; 1 (100 %), 1:1 (50 %), 1:2 (33.3%), 1:3 (25%) i.e the ratio of the amendment to soil.

b) No. of replicates per amendment = 3.

c) No. of weevils per replicate = 10 of mixed sex (1:1ratio).

**Experimental design:**

Completely Randomised Design (CRD), since the area used was uniform. First the treatments were allocated to pots/buckets at random. An area measuring 2mx10m was marked on the experimental area. A table of random numbers was used. The positions for placement of pots were marked on the area and each of the pots randomised to marked positions, using a table of random numbers. Each of the weevil releases/batches was randomised differently.

**Measurements**

**Weevil mortality:** The number of dead weevils were recorded at different time points i.e by observing the weevils after every 5 days in the pots for mortality. Any dead weevils were removed, and put into a moist chamber and observed for any *B. bassiana* fungal growth.



**Banana weevil larvae instars** recovered from the corms at sampling.

**corm damage:** this was assessed on two parts; the lower and upper parts. It was also recorded on the inner and outer sections. Recordings were made at destructive sampling of each release.

**amendment moisture content (MC) and temperature:** both of these parameters were taken at 10-day intervals. The MC was taken by weighing 20g of amendment in a weighed petridish and drying in an oven at 100<sup>o</sup>c for 24 hours. The temperatures were taken using thermometers that were inserted in the pots, below the mulch at 2.5cm depth.

**macrofauna:** 500cc of amendment was collected from each replicate at destructive sampling, spread on a white background and hand sorted for the different fauna. The fauna were identified to order level.

**soil characteristics:** samples were taken from each amendment and taken to the soils laboratory for routine analysis (N,P,K, Organic matter) plus nitrogen. The analysis was done at the beginning, after 2 months and at the end of the pot experiments.

Data on each of the above activities were entered into computer Excel sheets immediately after being collected.

**Management of the different activities:**

- a) *B. bassiana* production :*Magara Evarist*, Hellen Pedum (technician).
- b) *Experimental set up:* weevil collection, sexing, counting, amendment mixtures, weevil introductions into the pots and weevil mortality records; *Magara Evarist*.
- c) *Data collection:* *Magara Evarist*.

**Data files:** The data files are kept on C drive of in the following computers in a folder labelled ‘magara’; Caroline 2 computer, Banana 101computer, Africano computer, and students computer. In addition, the raw data are kept in a laboratory book, and in a box file clearly labelled ‘Magara Evarist MSc.’ The data are also on Yusuf’s computer in file **lab\_pot\_data.xls**.

**Plan for data analysis:** The data from the experiment will be subjected to statistical analysis using the SAS package. Analysis of variance will be carried out to determine the significance of treatment means and to make specific treatment comparisons using estimate statement in SAS PROC GLM.

**Data filenames:** *K\_Bb\_Formulations&SoilAmendments.xls*

**Protocol filename:** *Protocol\_SoilAmendments\_Pot\_ME2.doc*



### Samples of data sheets

(a) **SOIL TEMPERATURE ( $^{\circ}\text{C}$ )**; taken 2-3pm, at 10-day intervals.

Release..... DATE.....

| TREATMENTS                 | 10 DAYS |   |   | 20 DAYS |   |   | 30 DAYS |   |   |
|----------------------------|---------|---|---|---------|---|---|---------|---|---|
|                            | 1       | 2 | 3 | 1       | 2 | 3 | 1       | 2 | 3 |
| 1. Soil alone              |         |   |   |         |   |   |         |   |   |
| 2. Coffee husks            |         |   |   |         |   |   |         |   |   |
| 3. Manure alone            |         |   |   |         |   |   |         |   |   |
| 4. Coffee husks 1:1        |         |   |   |         |   |   |         |   |   |
| 5. Coffee husks 1:2        |         |   |   |         |   |   |         |   |   |
| 6. Coffee husks 1:3        |         |   |   |         |   |   |         |   |   |
| 7. Manure 1:1              |         |   |   |         |   |   |         |   |   |
| 8. Manure 1:2              |         |   |   |         |   |   |         |   |   |
| 9. Manure 1:3              |         |   |   |         |   |   |         |   |   |
| 10. Artificial fertilizers |         |   |   |         |   |   |         |   |   |

(b). **SOIL MOISTURE CONTENT (%)**; taken in the evening before watering, at 10-day intervals.

Period-----

Date.....

| TREATMENT S | 10 DAYS |   |   | 20 DAYS |   |   | 30 DAYS |   |   | Mean |
|-------------|---------|---|---|---------|---|---|---------|---|---|------|
|             | 1       | 2 | 3 | 1       | 2 | 3 | 1       | 2 | 3 |      |
| 1.          |         |   |   |         |   |   |         |   |   |      |
| 2.          |         |   |   |         |   |   |         |   |   |      |
| 3.          |         |   |   |         |   |   |         |   |   |      |
| 4.          |         |   |   |         |   |   |         |   |   |      |
| 5.          |         |   |   |         |   |   |         |   |   |      |
| 6.          |         |   |   |         |   |   |         |   |   |      |
| 7.          |         |   |   |         |   |   |         |   |   |      |
| 8.          |         |   |   |         |   |   |         |   |   |      |
| 9.          |         |   |   |         |   |   |         |   |   |      |
| 10.         |         |   |   |         |   |   |         |   |   |      |



(c) **Soil Biota (macro fauna):** No. and type of organisms/500cc of soil sample

**Period**.....

**Date**.....

| Type of amendment | Type of macrofauna | Nos |
|-------------------|--------------------|-----|
|                   |                    |     |
|                   |                    |     |
|                   |                    |     |
|                   |                    |     |

(d) **Weevil mortality**

**Release**.....

**Date**.....

|                       | 5 days |   |   |   |   |   | 10 days |   |   |   |   |   | 15 days |   |   |   |   |   | 20 days |   |   |   |   |   |
|-----------------------|--------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|---------|---|---|---|---|---|
| Replicates-           | 1      |   | 2 |   | 3 |   | 1       |   | 2 |   | 3 |   | 1       |   | 2 |   | 3 |   | 1       |   | 2 |   | 3 |   |
| Live/Dead-            | L      | D | L | D | L | D | L       | D | L | D | L | D | L       | D | L | D | L | D | L       | D | L | D | L | D |
| 1. Soil alone         |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 2. Coffee husks alone |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 3. Manure alone       |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 4. Coffee husks 1:1   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 5. Coffee husks, 1:2  |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 6. Coffee husks 1:3   |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 7. Manure 1:1         |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |
| 8. Manure, 1:2        |        |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |         |   |   |   |   |   |



**(e) No. and type of different Larval instars recovered at destructive sampling**

|            |      | LARVAL INSTARS |   |   |   |   |     |
|------------|------|----------------|---|---|---|---|-----|
| Amendments | Reps | 1              | 2 | 3 | 4 | 5 | 6&7 |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |
|            |      |                |   |   |   |   |     |



## **R7972 (Banana Weevils Project) – PROTOCOL ME3**

**TITLE:** EFFECT OF SOIL AMENDMENTS IN THE DELIVERY SYSTEM OF *BEAUVERIA BASSIANA* FOR CONTROL OF THE BANANA WEEVIL

**Scientists:** Dr. C.M. Nankinga (Principal Investigator) and Mr. Evarist Magara (M.Sc. student).

**Activity Leader:** Mr. Evarist Magara

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** University of Reading, IITA

**Start and end dates:** 2001 to March 2004

### **Research Background**

Bananas (*Musa* spp.) are an important food and cash crop in Uganda, and in other parts of the world (Karamura, 1992, Gold and Rubaihayo, 1993). The banana weevil, *Cosmopolites sordidus* has been recognised as one of the major constraints to banana production. Little control of the banana weevil has been achieved by use of current cultural, biological and chemical strategies. Recent studies (Kaaya *et al.*, 1993, Nankinga, 1994, 1999, Traore, 1995, and Godonou, 1999) indicate that the entomopathogenic fungus, *Beauveria bassiana* has a high potential as a biological control agent for the weevil in Africa. However, the biotic and abiotic factors that may influence the efficacy and persistence of this fungus under field conditions are not yet fully evaluated.

Therefore, this study aims at evaluating the efficacy and persistence of various *B. bassiana* formulations under laboratory conditions and evaluating the most effective formulation under pot and field conditions<sup>3</sup>. Five different levels of soil amendments in form of decomposed cow dung, coffee husks and an optimum level of artificial fertilizers will be evaluated. Soil characteristics in the different amendments will be monitored and related to the fungal efficacy and persistence. The study will be useful in establishing some of the vital field conditions required for effective use or non-use of *B. bassiana* for the biological control of the banana weevil.

**Key words:** *B. bassiana*, *C. sordidus*, efficacy, persistence, soil amendments, Bananas

### **Objective:**

To evaluate the effects of soil amendments, in the form of coffee husks, decomposed cow dung manure and artificial fertilizers, on the efficacy and persistence of *B. bassiana*.

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<sup>3</sup> This protocol relates to the on-station field experiment



## Materials and Methods:

**Location:** KARI field; part of block extension G.

### *Source of materials:*

| Material                                  | Source  |
|---|---|
| Cracked maize <i>B. bassiana</i> culture. | Prepared from KARI pathology laboratory, using the materials described under lab and pot expts. |
| Banana weevils                            | Stock reared in metallic drums in a shade outside the laboratory.                               |
| Mpologoma cultivar suckers                | Mubende district, Uganda.   |
| Decomposed cow dung                       | Private kraal in KARI senior quarters   |
| Coffee husks                              | Matugga coffee factory, near KARI.  |
| Artificial fertilizers                    | Balton (U) Ltd, in Kampala Industrial area.   |
| Furadan (carbofuran)                      | Sekalala enterprises, Kampala.  |

### *Preparation of experimental materials*

#### *(a) Amendments:*

The amendments were taken by volume. A plastic basin with a capacity of about 10,000cm<sup>3</sup> was used as a unit of measure. One unit of this was applied on each mat in the 45cm radius around the plant and mixed in the 10cm top layer of the soil. The recommended artificial fertilizer rate for bananas (D. Bwamiki pers.comm.) was applied; that is 69g of NPK, 28g of Urea, 31g of KNO<sub>3</sub>, 3g of MgSO<sub>4</sub>, applied four times per plant per year.

#### *(b) Banana weevils rearing*

The initial batch of banana weevils were trapped from KARI and farmers' banana plantations in Masaka using split pseudo stem traps. The weevils were reared from metallic drums on fresh banana corms under a shade as described by Nankinga (1999). The adult weevils were introduced to pared banana corms to oviposit eggs for seven days and there after the banana corms were maintained in metallic drums for 60 days to allow development of eggs to adults. The drums were covered with papyrus mats to avoid desiccation.

#### *(c) B. bassiana culturing*

One strain of the fungus, code G41, known to have high pathenogenicity to *C. sordidus*, superior growth and Sporulation was used. It was cultured in KARI insect pathology laboratory on cracked maize. The substrate was cultured following the modified diphasic method described by Nankinga (1999). It was then dried and packaged in 100g lots in polythene bags.

#### *(d) Banana suckers planting:*

Clean, pared Mpologoma cultivar suckers were purchased from Mubende District. Holes measuring 2ft x 2ft were dug in the field. One spadeful of decomposed cow dung manure was first placed into each hole before the planting.

#### *(e) B. bassiana and Weevils introductions:*

*B. bassiana* was applied in two splits; 100g at first and then another 100g after three weeks. The cracked maize *B. bassiana* culture was applied around each experimental plant in the field and carefully mixed in the top layer of the soil amendments. Dried banana mulch was placed on top of the fungus all around the plant. Weevils were marked with specific marks indicating the plot, amendment and release period. Ten weevils of mixed sex were released on each mat in the field.



**Key dates associated with the trial:**

| Activity   | Dates       |
|--|-------------|
| i) Banana field planting                         | March, 2002 |
| ii) Application of soil amendments               | 15/03/03    |
| iii) <i>B. bassiana</i> and Furadan application: |             |
| First split                                      | 26/03/03    |
| Second split                                     | 17/04/03    |
| iv) Weevil releases (at 30-day intervals):       |             |
| Batch I  | 17/04/03    |
| Batch II   | 17/05/03    |
| Batch III  | 17/06/03    |
| Batch IV   | 17/07/03    |

v) Destructive sampling: to be done at the end of all the weevil releases i.e 17/08/03.

vi) Weevil Mortality at 10-day intervals:

|            |           |          |          |
|------------|-----------|----------|----------|
| Batch I:   | 27/04/03, | 7/05/03, | 17/05/03 |
| Batch II:  | 27/05/03, | 7/06/03, | 17/07/03 |
| Batch III: | 27/06/03, | 7/07/03, | 17/07/03 |
| Batch IV:  | 27/07/03, | 7/08/03, | 17/08/03 |

vii) Amendment moisture content and temperature collected at 10-day intervals as for the weevil mortality above.

viii) Amendment macrofauna determined at 30-day intervals; 17/05/03, 17/06/03, 17/07/03, 17/08/03.

**Experimental treatments:**

a) There were 5 treatments, i.e. 1 control and 4 amendments, namely coffee husks, decomposed cow dung, artificial fertilizers (optimum), and furadan for comparison. Application of *B. bassiana* to these amendments was as described in 5.2(e) above

b) Banana weevils were released in all the treatment plots every 30 days. There were three releases. Banana weevils:10 of mixed sex (1:1ratio) were released on each mat.

**Experimental design**

The field was divided into 5 strips (the main plots) running down the field slope according to the treatments. The treatments were randomly assigned to these strips. Each strip was then divided into 4 sub-plots each with at least 9 mats and plots separated from each other by trenches measuring 1ft by 1ft. Pseudostem traps were placed in the trenches to limit weevil movement from one plot to another. The amendments were not randomized across all the 20 sub-plots because there was the fear that the



trenches would not be expected to control the potential passage of amendments from plot to plot within each strip.

#### ***Experimental units:***

Four of the sub-plots were contiguous down the slope of the field, and therefore they made up a single replicate for each of the amendment treatments.

#### **Measurements**

***Weevil mortality:*** The number of dead weevils were recorded at different time points i.e by observing the weevils after every 10 days around the plants and from the pseudostem traps for mortality. Any dead weevils were removed, and introduced into a moist chamber and observed for any *B. bassiana* fungal growth.

***amendment moisture content (%) and temperature ( $^{\circ}\text{C}$ ):*** : Both of these parameters were taken at 10-day intervals. The MC was taken by collecting samples from each plot and 20g of amendment weighed in a petridish and dried in an oven at  $100^{\circ}\text{C}$  for 24 hours. The temperatures were taken using thermometers that were inserted in the pots, below the mulch at 2.5cm depth.

***macrofauna:*** Soil samples were got from each treatment plot. Then by bulking and quartering, 500cc of amendment was obtained, spread on a white background and hand sorted for the different fauna. The fauna were counted and identified to order level at 30-day intervals

***soil characteristics:*** samples were taken from each treatment plot and taken to the soils laboratory for routine analysis plus nitrogen. The analysis was done at the beginning of the trial, after 30 days and after 60 days.

#### **Data:**

Data on each of the above activities were entered into computer Excel sheets immediately after being collected.

#### **Management of the different activities:**

a) *B. bassiana* production :*Magara Evarist*, Hellen Pedum (technician)and Recho Zawedde.

b) *Experimental set up:* weevil collection, sexing, counting, amendment mixtures, weevil introductions into the field and weevil mortality records; *Magara Evarist* and *Waswa William*.

c) *Data collection:* *Magara Evarist*.

**Data files:** The data files are kept on C drive of in the following computers in a folder labelled 'magara'; Caroline 2 computer, Banana 101computer, Africano computer, and students computer. In addition, the raw data are kept on floppy diskettes and CDS and in laboratory book and box file clearly labelled 'Magara Evarist MSc.' Data also on Yusuf's computer in file **field\_data.xls**.

**Plan for data analysis:** The data from the experiment will be subjected to simple descriptive procedures since true replication was not available.

**Data filenames:** *K\_BbSoil\_amendments\_field.xls*

**Protocol filename:** *Protocol\_SoilAmendments\_on-station\_ME3.doc*



### Sample data sheets

#### a) Weevil mortality from pseudostem traps

Date.....Release.....

| Trap no. | Treatment mark | live | Dead | Comments |
|----------|----------------|------|------|----------|
|          |                |      |      |          |
|          |                |      |      |          |
|          |                |      |      |          |
|          |                |      |      |          |
|          |                |      |      |          |
|          |                |      |      |          |

#### b) Weevil mortality from the exptal plants.

Batch..... Date.....

| Amendment | Plant No. | Status of weevils |      | Other marks |  | Comments |
|-----------|-----------|-------------------|------|-------------|--|----------|
|           |           | Live              | Dead |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |

#### c) Weevil mortality from non-exptal plants.

Release..... Date.....

| Amendment | Plant No. | Status of weevils |      | Other marks |  | Comments |
|-----------|-----------|-------------------|------|-------------|--|----------|
|           |           | Live              | Dead |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |
|           |           |                   |      |             |  |          |

#### d) Moisture content of the soil amendments

Release..... Date .....

| Amendment | Plots | Empty dish (g) | Fresh wt (g) | Dry wt (g) | M.C (%) | Comments |
|-----------|-------|----------------|--------------|------------|---------|----------|
|           |       |                |              |            |         |          |
|           |       |                |              |            |         |          |
|           |       |                |              |            |         |          |
|           |       |                |              |            |         |          |



**e) Temperature (°C) of the soil amendments**

Release.....

| Amendment | Plot | Temperature (0C) |         |         |         |
|-----------|------|------------------|---------|---------|---------|
|           |      | 0 days           | 10 days | 20 days | 30 days |
|           |      |                  |         |         |         |
|           |      |                  |         |         |         |
|           |      |                  |         |         |         |

**f) Soil fauna from the different amendments**

Release..... Date .....

| Amendment | Plot | Identity (order) | Numbers |
|-----------|------|------------------|---------|
|           |      |                  |         |
|           |      |                  |         |
|           |      |                  |         |
|           |      |                  |         |

**g) Summary of weevil mortality at 10-day intervals**

Release..... Dates.....

| TRT          | 10 days |               |                   |       | 20 days       |                   |       | 30 days       |                   |       | Total mortality |
|--------------|---------|---------------|-------------------|-------|---------------|-------------------|-------|---------------|-------------------|-------|-----------------|
|              | Plots   | Exptal plants | Non exptal plants | Traps | Exptal plants | Non exptal plants | Traps | Exptal plants | Non exptal plants | Traps |                 |
| Coffee Husks | 1       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 2       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 3       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 4       |               |                   |       |               |                   |       |               |                   |       |                 |
| A. fert.     | 1       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 2       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 3       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 4       |               |                   |       |               |                   |       |               |                   |       |                 |
| Manure       | 1       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 2       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 3       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 4       |               |                   |       |               |                   |       |               |                   |       |                 |
| Soil alone   | 1       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 2       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 3       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 4       |               |                   |       |               |                   |       |               |                   |       |                 |
| Furadan      | 1       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 2       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 3       |               |                   |       |               |                   |       |               |                   |       |                 |
|              | 4       |               |                   |       |               |                   |       |               |                   |       |                 |



## **R7972 (Banana Weevil Project) - PROTOCOL VT1**

**Title:** Banana weevil attractivity to pounded pseudostem tissues buried in the soil at various depths

**Lead Scientist:** Caroline Kukiriza (nee Nankinga)

**Activity Leader:** Venansio Tumuhaise

**Project funding:** DFID-CPP (R7972)

**Research Partners:** Simon Gowen (University of Reading)

**Start and end dates:** 1 March 2001 to 31 March 2004

### **Background:**

ICIPE, in Kenya, has been working on use of kairomone traps made with processed banana pseudostem material that is buried in the soil. High numbers of weevils are attracted to these traps (S. Lux, pers. comm.). There is a need however to establish how deep the materials should be buried in the soil to maximise the number of weevils caught in these traps.

### **Objectives:**

- (i) To determine the optimum depth at which buried pounded banana tissues attracts most banana weevils.
- (ii) To understand the influence of banana tissue fermentation on the attractiveness of the banana weevils to the tissues.
- (iii) To establish which of two cultivar-sources of banana tissues was more effective in attracting banana weevils to the traps.

### **Start and end dates of the trial:**

Started: 29/3/2003

Ended 23/4/2003

**Location:** On station, Kawanda Agricultural Research Institute (KARI).

### **Source of materials:**

Banana pseudostems of cultivar Atwalira - from on-station field

Banana pseudostems of Kayinja - from Senge farmer's field.

Buckets - from store at KARI

Soil - from the field on station.

### **Experimental details**

Five hundred grams (500g) of pounded banana pseudostem tissues of resistant and susceptible local cultivars, Kayinja and Atwalira respectively, were placed independently in buckets with soil at depths 0 (control), 5, 10, and 15 cm from the soil surface, and the surface mulched with dry banana leaves. Thus the treatments included:

1. Kayinja at 0 cm
2. Kayinja at 5 cm
3. Kayinja at 10 cm



4. Kayinja at 15 cm
5. Atwalira at 0 cm
6. Atwalira at 5 cm
7. Atwalira at 10 cm
8. Atwalira at 15 cm

Another treatment factor was different stages of tissue fermentation evaluated at 0 weeks (when freshly prepared), 1 week, 2 weeks, and 3 weeks.

Thus there were three treatment factors as follows:

- (i) cultivar (Kayinja, Mpologoma)
- (ii) depth of buried tissues (0cm, 5cm, 10cm, 15cm - from soil surface)
- (iii) fermentation stage (0 weeks, 1 week, 2 weeks, 3 weeks - post tissue preparation)

The 8 cultivar x depth treatment factors were set up in a completely randomised design (CRD), with each treatment replicated 3 times. Four sets of 24 buckets each were prepared at the same time. Each of the 4 sets corresponded to the 4 fermentation stages. All 72 buckets were placed in the shade for the duration of the experiment.

The 8 cultivar x depth treatment factors were randomly allocated to each of the sets with each treatment replicated 3 times. Ten banana weevils were released in each bucket of the first set at the start. After one week, another batch of 10 weevils was released in 24 buckets of the second set. Weevils were released in the third and fourth sets after 2 and 3 weeks respectively. The soil surface was mulched with dry banana leaves, and covered with mosquito net, tied around the rim of the bucket to restrict weevil exit from the buckets.

All the buckets were checked 4 days after weevil release and data collected on the number of weevils recovered from pounded tissues.

Management of the different activities:

Pounding banana pseudostem tissues: Field assistants.

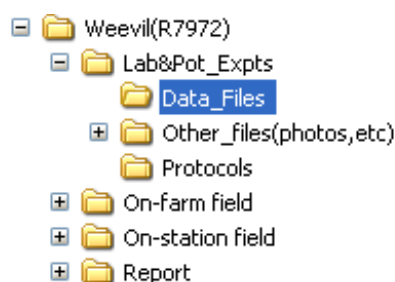
Data Collection: Venansio Tumuhaise, assisted by Field assistants.

Location of Computer data files:

On the following computers: Caroline 2, Banana students, and Africano.

**Data file name:** *Attractiveness\_kairomones\_buried\_tissues.xls*

Location of data file on archive:



**Protocol file name:** *Protocol\_Kairomones\_Buried\_Tissues\_VT1.doc*.



## **R7972 (Banana Weevil Project) - PROTOCOL VT2**

**Title:** Attractivity of different banana tissues to the banana weevils under field conditions

**Lead Scientist:** Caroline Kukiriza (nee Nankinga)

**Activity Leader:** Venansio Tumuhaise

**Project funding:** DFID-CPP (R7972)

**Research Partners:** Simon Gowen (University of Reading)

**Start and end dates:** 1 March 2001 to 31 March 2004

### **Background:**

It has been reported that traps made from corm materials are more attractive than pseudostem traps (Yaringano and Van der Meer, 1975; Cardenes and Arango, 1986; Bakyalire, 1992; Contreras, 1996 and Nankinga, 1999). However, ICIPE utilised pseudostem tissues rather than corm-based materials while designing the kairomone traps. There is a need to establish under field conditions, the benefits of using pseudostem materials of different banana cultivars.

### **Objectives:**

To establish

- (i) Whether buried pseudostem materials are actually more attractive than buried corm tissues
- (ii) Whether pounding improves attractiveness of the tissues as compared to mere chopping.
- (iii) Influence of cultivar-source of banana tissues on banana weevil attractiveness to the tissues.

### **Start and end dates of the trial:**

Started: 2/5/2003

Ended: 16/5/2003

Duration: 2 weeks

**Location:** On station, in the former Break Crop trial.

### **Source of materials:**

Pseudostems and corms cultivar Mpologoma - from on-station field (Beauveria bassiana trial, Block 10).

Pseudostems and corms of cultivar Kayinja – from Kilinyabigo, near Kawanda.

### **Experimental details:**

The experiment was conducted on station, KARI in an established well mulched banana field. The field consisted of a mixture of two local cooking banana cultivars; Namaliga and Ndiibwabalangira. Weevil count around the trap mats was estimated at the start of the trial by pseudostem trapping (3 traps/mat), with traps checked after 3 days and releasing back the trapped weevils to the respective mats. The banana tissues constituting treatment traps were obtained from a local resistant and susceptible cultivar Kayinja and Mpologoma respectively. Corm and pseudostem tissues were used for weevil attraction in chopped and pounded forms.







## **R7972 (Banana Weevil Project) - PROTOCOL VT3**

**Title:** Transmission of *B. bassiana* from inoculated to non-inoculated weevils under pot conditions

**Lead Scientist:** Caroline Kukiriza (nee Nankinga)

**Activity Leader:** Venansio Tumuhaise

**Project funding:** DFID-CPP (R7972)

**Research Partners:** Simon Gowen (University of Reading)

**Start and end dates:** 1 March 2001 to 31 March 2004

### **Background:**

It has been reported that disk on stump and pseudostem traps may aggregate weevils at delivery sites for entomopathogens (Kaaya et al., 1993; Contreras, 1996; Nankinga, 1999). In Costa Rica, Contreras (1996) and in Columbia, Castrillon (2000) applied *B. bassiana* to disc on stump taps. Contreras achieved 28% to 72% weevil infection, depending formulation and time after application while Castrillon realized 16% weevil infection. it has been urged that adult banana weevils may be attracted to banana tissue based traps without neccessarily keeping in/under the trap (S. Lux, pers.comm.). This suggests therefore that such weevils may get infected from an entomopathogen baited trap and disperse with the fungus. while in the habitat, the infected weevils may infect health individuals thus causing disease epizootics. However,there is no documented level of weevil attractivity of any trap that results in the aggregaion of a sufficient proportion of the weevils that may get infected and eventually infect the health ones in a habitat. This study was therefore conducted to establish the lowest proportion of infected weevils that can be released in a fixed population and result in total population mortality. Thus any trap that would aggregate an equivalent proportion of the weevils in a given habitat would sufficient as a delivery system for *Beauveria bassiana*.

### **Objectives:**

To establish the lowest proportion of infected weevils that can be released in a fixed population to achieve total population mortality.

### **Start and end dates of trial:**

Started: 29/3/2003

Ended 23/4/2003

**Location:** On station, KARI, in pots under shade.

### **Source of materials:**

Banana weevils - trapped from Mother Garden field on station, KARI

*B. bassiana* - Produced by the entomopathology laboratory at KARI

Buckets - from store at KARI

Soil - from the field on station.

Mulch - Banana dry banana leaves, picked from the field on station



**Experimental details:**

The experiment was conducted on-station, KARI in buckets. It involved releasing non-marked adult weevils infected with *B. bassiana* together with marked non-infected weevils in the buckets containing field-collected soil, and mulched with dry banana leaves. *Beauveria bassiana* was produced in laboratory at Kawanda by the modification of the production method used by Nankinga (1999). Weevil infection was ensured by keeping 150 weevils overnight in a bowl with 30g of cracked maize-formulated *B. bassiana*. Treatments involved varying ratios of inoculated : non-inoculated weevils in a population of 10 weevils per bucket as follows:

- (i). 0 inoculated : 10 non-inoculated weevils (control)
- (ii). 2 inoculated : 8 non-inoculated weevils 4 infected : 6 non-infected weevils
- (iii). 4 inoculated : 6 non-inoculated weevils
- (iv). 6 inoculated : 4 non-inoculated weevils
- (v). 8 inoculated : 2 non-inoculated weevils
- (vi). 10 inoculated : 0 non-inoculated weevils

The buckets were covered with a mosquito net tied around the bucket with straps to restrict escape of the introduced weevils and/or entry of external weevils. The buckets were set up in a completely randomised design (CRD) with each treatment replicated 5 times.

**Management of the different activities:**

Pounding banana pseudostem tissues: Field assistants.

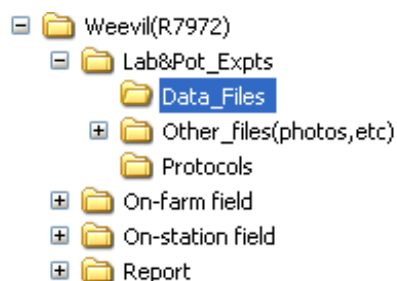
*B. bassiana* production: Laboratory technicians (Hellen, Rachael)

Data Collection: Venansio Tumuhaise, assisted by Field assistants.

**Computer data files:**

On the following computers: Caroline 2, Banana students, and Aficano with the following directories:

**Data file name:** *Dissemination\_inoculated\_non-inoculated\_weevils.xls*

**Location of data file on archive:**

**Protocol file name:** *Protocol\_Dissem\_inocul\_non-inocu\_VT3.doc*.



## **R7972 (Banana Weevil Project) - PROTOCOL VT4**

**Title:** Ability of *B. bassiana* conidia to adhere to the banana weevil in a semiochemical-baited trap

**Lead Scientist:** Caroline Kukiriza (nee Nankinga)

**Activity Leader:** Venansio Tumuhaise

**Project funding:** DFID-CPP (R7972)

**Research Partners:** Simon Gowen (University of Reading)

**Start and end dates:** 1 March 2001 to 31 March 2004

### **Background:**

The potential of using *Beauveria bassiana* has been studied in Uganda, and results reported with regard to *C. sordidus* control are promising. There is need to develop an effective delivery system to target the insects. Weevils attracted to a *Beauveria bassiana*-contaminated site would get infected, and if the infected weevils disperse they infect other health individuals in the habitat. Use of semiochemicals (pheromones and kairomones) as lures for dissemination of *B. bassiana* has been reported effective for other beetles. *Cosmopolites sordidus* infected with *B. bassiana* can transfer the pathogen to non-infected individuals. Information on the role of semiochemicals in disseminating *B. bassiana* with regard to weevil control is lacking. This study aims to address this issue.

### **Objectives:**

To determine

- (i) the time spent by a weevil in a *B. bassiana* containing trap,
- (ii) estimate the amount of *B. bassiana* spores that adhere to the weevil after exiting the fungus-treated trap.

### **Start and end dates of trial:**

Started: 15/10/2003

Ended 22/10/2003

**Location:** In the laboratory (darkroom) at Sendusu, Uganda.

### **Source of materials:**

Banana weevils - trapped from Masaka

*B. bassiana* - Produced by the entomopathology laboratory at KARI

Banana pseudostems - Got from Atwalira field at Sendusu

Olfactometer - Purposively designed at Sendusu with PVC pipes and gallons bought from hardware shop.

### **Experimental details:**

The study was conducted in a darkroom at Sendusu – Namulonge- using a dual choice olfactometer. Treatments were evaluated were:

- |                               |                     |
|-------------------------------|---------------------|
| 1. Pheromone                  | 3. Split pseudostem |
| 2. Pounded pseudostem tissues | 4. Control (air)    |



The pounded pseudostem tissues were prepared by pounding a piece of pseudostem (cv. Atwalira) in a mortar. One sachet of pheromone was used. The following comparisons were made using the dual choice olfactometer:

- (a) Pheromone/control
- (b) Pounded pseudostem tissues/control
- (c) Split pseudostem/control

All the three comparisons were conducted on a single day and a day constituted a replication. The experiment was repeated 3 times, each conducted on an independent date. Thus a total of 4 replications were used. The same lot of *B. bassiana* was used in a replication to minimize variation emanating from lot differences. In addition, the same piece of pseudostem was used to provide the split pseudostem and pounded tissues for the same replication. The different comparisons were run sequentially, one after another to minimize accumulation of odours diffusing from the different materials in the dark room. After each comparison cycle, a fan was switched on for 20 min. to blow out air saturated with odours.

Ten adult banana weevils were released at the centre of the connector. The time when a weevil entered and when it exited the trap was recorded, and the time spent by the weevil in the trap was computed. The weevil was picked with a pair of forceps as it moved out of the fungus, and rinsed in 10 ml of distilled water with a drop of liquid soap. *B. bassiana* spores in the suspension were counted using a haemocytometer.

Spores per weevil,  $S = (X * 5 * 104) * 10$ ; where X is the mean spore count from the 5 diagonal squares of the haemocytometer.

#### **Management of the different activities:**

Pounding banana pseudostem tissues: Field assistant (K. Patrick - Sendusu).

*B. bassiana* production: Laboratory technicians (Hellen, Rachael - KARI)

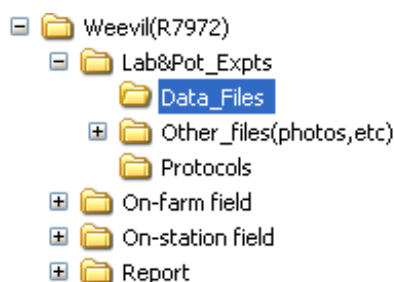
Data Collection: Venansio Tumuhaise, assisted by Field assistant (Sendusu).

#### **Computer data files:**

On the following computers: Caroline 2, Banana students, and Aficano with the following directories:

**Data file name:** *Dissemination\_lab\_trap\_infection.xls*

Location of data file on archive:



**Protocol file name:** *Protocol\_Dissem\_labtrap\_infection\_VT4.doc*



## **R7972 (Banana Weevil Project) - PROTOCOL VT5**

**Title:** Banana weevil attraction range of various semiochemical traps, and delivery of *B. bassiana* with the traps to control the banana weevil

**Lead Scientist:** Caroline Kukiriza (nee Nankinga)

**Activity Leader:** Venansio Tumuhaise

**Project funding:** DFID-CPP (R7972)

**Research Partners:** Simon Gowen (University of Reading)

**Start and end dates:** 1 March 2001 to 31 March 2004

### **Objectives:**

The experiment was conducted on-station (Kawanda) with the following objectives:

- (i) to evaluate the ability of traps made out of pheromone, split pseudostem, and pounded corm tissues superimposed with split pseudostem to attract banana weevils released at various distances from the treatment trap.
- (ii) to assess the mortality of weevils attracted to the traps over time.

### **Start and end dates of trial**

Started: 8/12/2002.

Ended: 5/1/2003

Duration: 4 weeks

**Location:** On station, in the former Break Crop trial.

### **Source of materials:**

Pheromone: Imported from Costa Rica (Chemtica Industry)

Beauveria bassiana: Produced locally by the entomopathology lab at Kawanda

Pseudostems: Collected from the *B. bassiana* trial at Kawanda.

Weevils: trapped from the experimental field

### **Experimental details:**

Experimental plots of 3 x 7 banana stools spaced at 3m were used in this study. The middle mat of the central line was targeted while placing the treatment traps. Ten banana weevils (5 males : 5 females) were marked and released per mat in the central line. A total of 70 marked weevils (35 males and 35 females) were released per plot. Males and females were marked differently with a mark on the right and left side of the thorax respectively. Weevils released at the same mat were given an identical mark, made by cutting the elytra with a sharp knife.

Weevils were marked as follows;

trap mat weevils = one mark on top-left;

3 m upslope = 1 mark on middle left,

6 m upslope = 1 mark on lower left, and

9 m upslope = 1 mark on top-right; then

3 m down slope = 1 mark on middle right,



6 m downslope = 1 mark on lower right, and  
9 m downslope = 1 mark cutting across the middle of right and left elytra.

The following treatment traps were evaluated: 1) Pheromone trap, 2) Pounded corm tissues superimposed with split pseudostem, 3) Exposed Pounded corm tissues, 4) Split pseudostem trap alone, and 5) Control

The trap made out of pounded corm tissues superimposed with split pseudostem was designed by placing pounded banana corm tissues (cv. Mpologoma) in a small hole dug up in the soil and covered with a piece of split pseudostem to keep the materials fermenting and minimise desiccation. A standard volume of pounded corm tissues equivalent to a standard (25cm – length) pseudostem trap (crashed) was used. Exposed pounded corm tissues - based trap was designed by mere placing of the pounded tissues in a small, without covering with split pseudostem. The pheromone trap (Cosmolure+) was delivered with a pitfall trap by hanging the pheromone sachet from the lid of the bucket with a nylon string. The split pseudostem trap (cv. Mpologoma) was directly placed on the soil surface. The control trap constituted a water-treated pitfall trap described for the pheromone trap but without the pheromone sachet. Each of the traps was set close to the middle mat, and 200g of *Beauveria bassiana* spread around the traps.

The experiment was set up in a Completely Randomised Design (CRD), with each treatment replicated three (3) times. Traps were inspected, and data collected at 4-day intervals for a period of one month (8/12/2002 – 5/1/2003). Weevils collected from the traps were maintained in the laboratory to monitor *Beauveria* growth. Split pseudostem traps, both sole and those covering the pounded corm tissues, were replaced after every 8 days, i.e. after every 2 data collection sessions. The pounded corm tissues and pheromone sachet were used over the whole cycle (i.e. one month).

**Management of the different activities:**

Pounding banana pseudostem tissues: Field assistants.

Data Collection: Venansio Tumuhaise, assisted by Field assistants.

**Computer data files:**

On the following computers: Caroline 2, Banana students.

**Data file name:** *K\_Attractiveness\_kairomones\_recapture.xls*

**Protocol file name:** *Protocol\_AttractKairomonesRecapture\_VT5.doc*



## **R7972 (Banana Weevil Project) - PROTOCOL VT6**

**Title:** **Banana weevil attractivity to banana tissues traps treated with *B. bassiana*, and fungal infection of the trapped weevils.**

**Lead Scientist:** Caroline Kukiriza (nee Nankinga)

**Activity Leader:** Venansio Tumuhaise

**Project funding:** DFID-CPP (R7972)

**Research Partners:** Simon Gowen (University of Reading)

**Start and end dates:** 1 March 2001 to 31 March 2004

### **Specific objectives:**

1. To evaluate relative attractiveness of the banana weevil to different modified disk on stump traps.
2. To assess field infectivity of *B. bassiana* against the banana weevil under the different modified disk on stump traps and split pseudostem.
3. To assess field-dissemination of *B. bassiana* from modified disk on stump traps.

### **Start and end dates of the trial**

Started: 8/8/2003

Ended 13/9/2003

**Location:** On station, KARI and Senge About 3 km from Senge.

### **Experimental details:**

The experiment was conducted on station, Kawanda and in Senge farmer fields, with two replicates on station and other two replicates in Senge. The two replicated in Senge occupied two fields that were about 1 km apart, and were under different management practices. Both fields were close to the homesteads, and therefore were always supplied with kitchen refuses and other residues. In one of the fields, the farmer was originally conducting pseudostem trapping with the traps mainly set on mats where a bunch has been harvested and to a small extent on other mats. The farmer continued trapping within the same field during the experimental period. This field was under good mulch cover. In the other field, there was limited mulch, and at two weeks after trial initiation, the farmer ploughed and planted beans within this field, heaping the mulch around the area near the banana mats that was unploughed. The onstation field was big enough to accommodate two replicates. This field was under proper management with good mulch cover. Mats with flowered banana plants or harvestable bunches were selected for use in this study. Pre-treatment pseudostem trapping (2 traps/mat) was conducted in all plots, targeting the selected trap mats and a sample of five mats around the each of the selected mats. The pseudostem traps were checked after 3 days, to establish initial weevil count per the trap mat and the neighbouring mats. Samples of the trapped weevils per plot were taken to the laboratory to monitor for weevil mortality and growth of *B. bassiana* due to natural infection from the field. The other weevils were released back to their respective mats.



*The following treatments were used:*

1. Disk-on-stump trap with one disk + *B. bassiana*
2. Disk-on-stump with two disks + *B. bassiana*
3. Pounded pseudostem tissues + *B. bassiana*
4. Split pseudostem trap + *B. bassiana*
5. *B. bassiana* alone (control)

Two hundred grams (200g) of *B. bassiana* formulated on cracked maize were applied around the trap and covered with banana trash. The *B. bassiana* control involved applying 200g of the fungus around a trap-free banana mat. The treatments were allocated to the experimental plots in a randomised complete block design (RCBD), with each treatment replicated 4 times. Two replicates were set on station and the other 2 replicates in Senge. The experiment were ran for two months. The traps were checked at 3-day intervals for 2 months. Weevils from the traps were taken to the laboratory to monitor for mortality and *B. bassiana* growth. From the treatment traps and the *B. bassiana* control, 20g samples of *B. bassiana* were collected and taken to the laboratory in dry petri-dishes. Ten adult weevils were released into the *B. bassiana* containing dishes and left in contact for 24 hours. The weevils were transferred to petri-dishes lined with moist tissue to monitor for mortality and *B. bassiana* growth at 5-day intervals for 30 days. Split pseudostem traps replaced at 6-day intervals. Post-treatment pseudostem trapping (2 traps/mat) was re-conducted on the trap mat and the sample of 5 - 5 mats next to the trap mat at 2-week intervals for 1 month. Total number of weevils trapped per mat was recorded, and weevils from the trap mat and from the neighbour mats were taken to the laboratory and independently maintained in petri dishes lined with moist tissue paper to monitor for mortality and *B. bassiana* growth on the dead weevils at 5-day intervals for 30 days.

**Management of the different activities:**

Pounding banana pseudostem tissues: Field assistants.

Data Collection: Venansio Tumuhaise, assisted by Field assistants.

**Computer data files:**

On the following computers: Caroline 2, Banana students

**Data file name:** *K\_Attractiveness\_Dissemination\_Kari\_Senge.xls*

**Protocol file name:** *Protocol\_Attraciveness\_kari\_senge\_VT6.doc*



## **R7972 (Banana Weevils Project) - Protocol CK1**

**Title:** Protocol for the effect of banana spacing on efficacy and persistence of *Beauveria bassiana* in the management of the banana weevil

**Scientists:** Dr. C.M. Nankinga (Principal Investigator); Mr. R. Kawuki; Mr. E. Magara (M.Sc. student); Mr. V. Tumuhaise (M.Sc. student); Mr. W. Wasswa (Field technician); Mr. S. Ddungu (Field technician); Mrs. O.P. Hellen (Laboratory technician); Mr. Bony, Mr. Nkubi, Charles, and Sam (Field assistants).

**Activity Leader:** Dr. C.M. Nankinga

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** University of Reading and International Institute of Tropical Agriculture (IITA)

**Start and end dates:** October 2001 to March 2004

### **Research Background**

The entomopathogen *B. bassiana* is highly infective against the banana weevil under laboratory conditions, but very disappointing under field conditions (Grodén and Dunn, 1996). Under field conditions, several soil biotic and abiotic factors limit the survival and establishment of *B. bassiana* in the management of the banana weevil, a soil dwelling pest. However, implementation of appropriate management practices can increase the persistence of *B. bassiana*. Light in the form of solar radiation is highly detrimental to entomopathogens (Ignoffo et al., 1977), and thus, efforts that minimize direct exposure of *B. bassiana* conidia to solar radiation can be useful in this aspect. Manipulation of plant spacing can both minimize solar radiation reaching the soil surface, and help build up of optimal humidity required by *B. bassiana* within the soil environment; these aspects may result into increased persistence of *B. bassiana* within the soil ecosystem. Alternatively, increasing the application rates and or repeated applications of *B. bassiana* can help replace the degraded *B. bassiana* within the soil ecosystem, and hence increase the persistence of the entomopathogen within the soil ecosystem. Unfortunately, these aspects have not been quantified, and thus this study attempts to address this aspect.

### **Objectives of the activity:**

- i) To evaluate the effect of banana spacing on the efficacy and persistence of *B. bassiana*.
- ii) To evaluate the effect of spacing on banana agronomic performance.

### **Materials and Methods**

**Location:** On-station (Kawanda) in block 10 and extension G.



### **Source of materials:**

| <b>Material</b>                              | <b>Source</b>   |
|--|---|
| Mpologoma cultivar Suckers                   | Sembabule District, Uganda.   |
| Artificial fertilizers                       | Balton (U) Ltd, and Green House Chemicals Ltd, Kampala, Uganda.                       |
| Farm yard manure                             | Ugachick Poultry Breeders, Gayaza Road, Uganda.                                       |
| Mulching material; swamp and elephant grass. | Ssenge swamp, near Kawanda.   |
| Cracked maize formulated- <i>B. bassiana</i> | Prepared by the Insect Pathology Laboratory, Kawanda Agricultural Research Institute. |

**Experimental design:** Split Unit Design Randomised Complete Block Design (CRBD). Each replication had as main units, the 3 spacings, the 2 *B. bassiana* applications, and a control without *B. bassiana* application. Split units arose because the *B. bassiana* plots were further vertically split into 2 equal parts to accommodate the two application regimes. Replications 1 and 2 were allocated to Block 10 and rep 3 to extension G.

### **Experimental treatments:**

Spacing (3 levels): 2x2 m, 2.5x2.5 m, and 3x3 m.

*B. bassiana* application dosages (2 levels): 100g and 200g per mat.

*B. bassiana* application intervals (2 levels): 2 monthly and 3 monthly.

Number of replications = 3

### **The field:**

The field was originally under fallow with elephant grass (*Penisetum* sp.). The field was first ploughed using a tractor and then marked according to the required spacings. Holes measuring 2ft wide by 2ft deep were dug in the marked positions. One spade full of farm-yard manure was then put in each of the holes, to which one pared sucker of the mpologoma cultivar was planted and completely covered with soil.

### ***B. bassiana* production:**

Maize formulated *B. bassiana* was produced by the Insect Pathology Laboratory located at Kawanda Agricultural Research Institute, Uganda. The fungus was produced on cracked maize as the substrate following the modified diphasic method as described by Nankinga (1999).

### **Dates associated with the trial:**

- Planting date: Oct. 2001.
- Fertilizer application regimes: The recommended NARO fertilizer application for bananas was applied around each mat; 69g of NPK, 28g of Urea, 31g of KNO<sub>3</sub>, 3g of MgSO<sub>4</sub>, applied four times per plant per year, as per the following schedule;

| <b>Application Schedule</b> | <b>Dates</b>  |
|-----------------------------|---------------|
| First                       | 20/06/02      |
| Second                      | 4/10/2002     |
| Third                       | 28/4/2003     |
| Fourth                      | For Oct. 2003 |



c) Schedule for *B. bassiana* production

| Reps.    | Sucrose-yeast preparation | Inoculation of cracked maize | Drying       | Storing      | Application  |
|----------|---------------------------|------------------------------|--------------|--------------|--------------|
| <b>1</b> | 30/08/02                  | 4/09/02                      | 11/09/02     | 30/09/02     | 1. 26/10/02  |
|          | 21/11/02                  | 26/11/02                     | 2/12/02      | 17/12/02     | 2a. 23/12/02 |
|          | 12/12/02                  | 17/12/02                     | 23/12/02     | 7/01/03      | 2b. 26/01/03 |
|          | 31/01/03                  | 5/02/03                      | 11/02/02     | 22/02/03     | 3a. 23/02/03 |
|          | 28/03/03                  | 2/04/03                      | 8/04/0222/22 | 22/04/03     | 3b. 26/04/03 |
|          | 11/03/03                  | 16/03/03                     | /03/03       | 28/03/03     | 4a.23/04/03  |
|          |                           | 6/7/03                       | 12/7/03      | 24/7/03      | 4b.28/07/03  |
|          |                           | 21/5/03                      | 27/5/03      | 11/6/03      | 5a. 24/6/03  |
|          |                           | 29/10/03                     | 4/11/03      | 18/11/03     | 5b. 28/11/03 |
|          |                           | 14/8/03                      | 20/8/03      | 1/9/03       | 6a. 26/9/03  |
| <b>2</b> |                           |                              |              |              | 6b           |
|          | 3/10/02                   | 8/10/02                      | 14/10/02     | 28/10/02     | 1. 11/11/02  |
|          | 5/12/02                   | 10/12/02                     | 16/12/02     | 2/01/03      | 2a. 10/01/03 |
|          | 24/01/03                  | 29/01/03                     | 4/02/03      | 10/02/03     | 2b. 11/02/03 |
|          | 14/02/03                  | 20/02/03                     | 25/02/03     | 7/03/03      | 3a. 10/03/03 |
|          |                           | 18/4/03                      | 22/4/03      | 6/5/03       | 3b. 13/5/03  |
|          |                           | 23/4/03                      | 29/4/03      | 12/5/03      | 4a. 13/5/03  |
|          |                           | 6/8/03                       | 12/8/03      | 31/8/03      | 4b. 2/9/03   |
|          |                           | 29/6/03                      | 5/7/03       | 14/7/03      | 5a. 17/7/03  |
|          |                           | 12/11/03                     | 18/11/03     | 30/11/03     | 5b. 5/12/03  |
| <b>3</b> |                           | 21/8/03                      | 27/8/03      | 8/9/03       | 6a. 11/9/03  |
|          |                           |                              |              |              | 6b           |
|          | 17/10/02                  | 23/10/02                     | 29/10/02     | 14/11/02     | 1. 28/11/02  |
|          | 3/01/03                   | 8/01/03                      | 14/01/03     | 27/01/0327/0 | 2a. 28/01/03 |
|          | 7/02/03                   | 12/02/03                     | 18/02/03     | 2/03         | 2b. 28/02/03 |
|          | 28/02/03                  | 5/03/03                      | 11/03/03     | 19/03/03     | 3a. 28/03/03 |
|          |                           | 4/5/03                       | 10/5/03      | 26/5/03      | 3b. 30/5/03  |
|          |                           | 15/5/03                      | 21/5/03      | 29/5/03      | 4a.28/05/03  |
|          |                           | 18/8/03                      | 24/8/03      | 3/9/03       | 4b.10/9/03   |
|          |                           | 9/7/03                       | 15/7/03      | 30/7/03      | 5a. 1/8/03   |
| <b>3</b> |                           | 19/11/03                     | 25/11/03     | 6/12/03      | 5b. 12/12/03 |
|          |                           | 17/8/03                      | 23/8/03      | 2/9/03       | 6a. 10/10/03 |
|          |                           |                              |              |              | 6b           |

Note: Application regimes: a= 2 month interval; b= 3month interval.



d) *B. bassiana* application regimes

| REPLICATES             | PLOT No. | SPACING (m) | <i>B. BASSIANA</i> DOSAGE(g) | DATE OF APPLICATION  |
|------------------------|----------|-------------|------------------------------|--|
| <b>1 (Block 10)</b>    | 1        | 2x2         | Control                      | 1. 26/10/02<br>2a. 23/12/02<br>2b. 26/01/03<br>3a. 23/02/03<br>3b. 26/04/03<br>4a.23/04/03<br>4b.28/07/03<br>5a. 24/6/03<br>5b. 28/11/03<br>6a. 26/9/03<br>6b. |
|                        | 2        | 2x2         | 200                          |  |
|                        | 3        | 2x2         | 100                          |  |
|                        | 4        | 2.5x2.5     | 200                          |  |
|                        | 5        | 2.5x2.5     | 100                          |  |
|                        | 6        | 2.5x2.5     | Control                      |  |
|                        | 7        | 3x3         | Control                      |  |
|                        | 8        | 3x3         | 100                          |  |
|                        | 9        | 3x3         | 200                          |  |
| <b>2 (Block 10)</b>    | 10       | 2x2         | Control                      | 1. 11/11/02<br>2a. 10/01/03<br>2b. 11/02/03<br>3a. 10/03/03<br>3b. 13/5/03<br>4a. 13/5/03<br>4b. 2/9/03<br>5a. 17/7/03<br>5b. 5/12/03<br>6a. 11/9/03<br>6b     |
|                        | 11       | 2x2         | 200                          |  |
|                        | 12       | 2x2         | 100                          |  |
|                        | 13       | 2.5x2.5     | Control                      |  |
|                        | 14       | 2.5x2.5     | 100                          |  |
|                        | 15       | 2.5x2.5     | 200                          |  |
|                        | 16       | 3x3         | 100                          |  |
|                        | 17       | 3x3         | 200                          |  |
|                        | 18       | 3x3         | Control                      |  |
| <b>3 (Extension G)</b> | 19       | 2x2         | 200                          | 1. 28/11/02<br>2a. 28/01/03<br>2b. 28/02/03<br>3a. 28/03/03<br>3b. 30/5/03<br>4a.28/05/03<br>4b.10/9/03<br>5a. 1/8/03<br>5b. 12/12/03<br>6a. 10/10/03<br>6b    |
|                        | 20       | 2x2         | 100                          |  |
|                        | 21       | 2x2         | Control                      |  |
|                        | 22       | 2.5x2.5     | 100                          |  |
|                        | 23       | 2.5x2.5     | 200                          |  |
|                        | 24       | 2.5x2.5     | Control                      |  |
|                        | 25       | 3x3         | 200                          |  |
|                        | 26       | 3x3         | Control                      |  |
|                        | 27       | 3x3         | 100                          |  |

*Note:* Application dates are different for the replicates because of the limited production of *B. bassiana*.



**Measurements:**

Data in the field were collected on the following parameters:

- Plant girth (cm) taken at 1m from the ground using a tape measure.
- Plant height (cm) using a calibrated stick.
- Number of suckers per mat.
- Number of leaves (mother & daughter) per plant.
- Flowering date (days) determined at the first sight of shooting.
- Harvest date determined at physiological maturity.
- Bunch weight (kgs).
- Number of clusters per bunch.
- Corm weevil damage, determined on upper section on both inner and outer corm sections; this was done on recently harvested plants.
- Weevil density per mat, determined using a single pseudostem trap per mat on a monthly intervals.
- Soil temperature and moisture
- Incident solar radiation and Leaf Area Index (LAI)
- Soil analysis and leaf analysis

Data on each of the above activities were entered into computer Excel sheets immediately after being collected.

*Note:* Application regimes: a= 2 month interval; b= 3month interval.

**Management of the different activities:**

- i) Overall supervision of the whole trial: Dr. C. Nankinga.
- ii) *B. bassiana* production and application: Hellen Pedum (technician), Magara Evarist, Venansio Tumuhaise, Wassawa William, and Kawuki Robert.
- iii) Banana plantation management (weeding, detrashing, trench maintenance): Bony, Charles, Sam, Nkubi.
- iv) Data Collection: Wasswa, and Josephine.

**Variables to be analysed:**

- 1) Agronomic parameters: for entering and processing data on plant height, girth, number of suckers, leaves, flowering dates, harvesting dates, number of clusters, and bunch weight.



2) Corm damage: for entering and processing data on corm damage of first, second and third plant cycles.


3) Weevil infectivity: for data on weevil abundance, and infectivity in the field.

**Plan for data analysis:** The data from the experiment will be subjected to statistical analysis using the SAS package. Analysis of variance will be carried out to determine the significance of treatment means and use the estimate statement and fit a regression model using a solution option in SAS PROC MIXED. The analysis of variance structure is outlined below:

| Source of Variation     | df |
|-------------------------|----|
| Blocks                  | 2  |
| Spacing                 | 2  |
| Dosage                  | 2  |
| Spacing x Dosage        | 4  |
| Main plot residual      | 16 |
| Main plot Total         | 26 |
| Application Regime      | 1  |
| Spacing x Regime        | 2  |
| Dose x Regime           | 2  |
| Spacing x Dose x regime | 4  |
| Split plot residue      | 9  |
| Split plot Total        | 44 |

*Note:* Unbalanced treatment structure implies the analysis is not straight forward.

#### Data file names:

|   |          |                        |                  |
|---|----------|------------------------|------------------|
|  K_Spacing_Agronomy.xls                | 1,272 KB | Microsoft Excel Wor... | 16/01/2004 10:49 |
|  K_Spacing_cormdamage.xls.xls          | 719 KB   | Microsoft Excel Wor... | 16/01/2004 10:59 |
|  K_Spacing_Meteorological data.xls     | 44 KB    | Microsoft Excel Wor... | 16/01/2004 10:48 |
|  K_Spacing_soil and plant analysis.xls | 35 KB    | Microsoft Excel Wor... | 05/12/2003 11:25 |
|  K_Spacing_suckers.XLS                 | 551 KB   | Microsoft Excel Wor... | 16/01/2004 09:45 |
|  K_Spacing_weevildamage.xls            | 499 KB   | Microsoft Excel Wor... | 16/01/2004 09:48 |
|  K_Spacing_weevils.xls                 | 845 KB   | Microsoft Excel Wor... | 16/01/2004 09:43 |

**Protocol file name:** *Protocol\_BbassianaEfficacy\_onstation\_CK1.doc*



## **R7972 (banana weevils Project) - Protocol CK2**

**Title:** Protocol for the on-farm trial investigating the efficacy of *Beauveria bassiana* in the management of the banana weevil

**Scientist:** Dr. C.M. Nankinga (Principal Investigator); Mr. R. Kawuki; Mr. E. Magara (M.Sc. student); Mr. V. Tumuhaise (M.Sc. student); Mr. W. Wasswa (Field technician); Mr. S. Ddungu (Field technician); and Mrs. O.P. Hellen (Laboratory technician).

**Activity Leader:** Dr. C.M. Nankinga

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** University of Reading, International Institute of Tropical Agriculture (IITA)

**Start and end dates:** 2001 to March 2004.

### **Research Background**

The banana weevil (*Cosmopolites sordidus* Germar), has for long been, and is still a major constraint for banana production in central Uganda, where complete crop failure has been reported (Gold et al., 2001). Unfortunately, the East African highland bananas, which are preferred by the farming community, are hardest hit. In response to this threat, several control options have been developed and implemented to address the banana weevil problem, but with varying levels of success. Thus, the International Institute of Tropical Agriculture (IITA) and the Uganda National Banana Research Programme (UNBRP) are advocating for the integrated pest management (IPM) approach; biological control using the entomopathogen *Beauveria bassiana* is an important component of this strategy. Indeed, candidate strains of *B. bassiana* that cause high mortality in the laboratory, and which have shown promise in on-station field studies have been identified (Nankinga, 1999). Clearly, it's necessary that on-station generated technologies are verified on-farm, before dissemination to the wider farming community. Besides, it's necessary to test the persistence and efficacy of *B. bassiana* under the much variable and complex farmer's conditions. This study is set out to investigate the efficacy and persistence of *Beauveria bassiana* in the management of the banana weevil under farmer's conditions.

### **Objectives of the study**

- a) Quantify the field efficacy of *Beauveria bassiana* in the management of the banana weevil under two agronomic practices
- b) Familiarise farmers with biological control agents used in management of the banana weevil.

### **Materials and Methods**

**Location:** The trial has so far been implemented on ten farmers' fields in Masaka district, covering six parishes: kisseka, kakamba, katoke, kikenene and kiwangala parishes.



**Source of materials:** Maize formulated *Beauveria bassiana* is the only material input; this is being produced at the insect pathology laboratory at Kawanda Agricultural Research Institute.

**Experiment layout:** At each farmer's field, maize formulated *B. bassiana* at a rate of 200g per mat was applied in two different ways: 1) applied around the banana mats and then mulched, and 2) applied 30-45 cm away from banana mats and then mulched. These are commonly used agronomic practices in banana plantations, and were therefore used in the evaluation of *Beauveria bassiana*. Twenty banana mats represented each agronomic practice. For comparison purposes, 20 banana mats were included to constitute the control treatment. The experiment layout was a randomised complete block design, with each farmer being a replicate; thus 10 replicates were used in the study.

**Data collection:** At each farmer's field, baseline corm damage assessment was done on 7 to 10 recently harvested plants; assessment was done on the upper corm section, on both the inner and outer corm sections. Immediately after *B. bassiana* application, sword suckers on each of the 20 mats per plot were tagged, and will be used for corm damage assessment after harvest; this damage will be compared with the baseline corm damage, and used to evaluate the efficacy of *B. bassiana* in the management of the banana weevil. Additionally, pseudostem traps will be placed per mat on a monthly interval, and used to monitor banana weevil infectivity and abundance under the imposed treatments. Soil samples will be taken from (0-10 cm and 10-20 cm) depths at each farm where *Beauveria bassiana* was applied, and were thereafter analysed at Kawanda Agricultural Research Institute. Additionally, observations on cultivars grown and employed agronomic management practices were made.

### **Dates associated with the trial implementation**

**Planting date:** The trial was established in two phases: 3<sup>rd</sup> July and 18<sup>th</sup> August 2003. The trial implementation was split because of the low fungus production at the insect pathology laboratory at Kawanda. *Beauveria bassiana* applications will be done at 3-month interval for four more times.

### **Management of the different activities**

- a) Overall supervision of the trial: Dr. C.M. Nankinga
- b) *Beauveria bassiana* production and application: Ms. Hellen Pedum, Mr. E. Magara, Mr. R. Kawuki, Mr. W. Wasswa, and Mr. S. Ddungu.
- c) Data collection: Mr. E. Magara, Mr. R. Kawuki, Mr. W. Wasswa, and Mr. S. Ddungu.

### **Variables to analyse:**

- a) Corm damage: for processing baseline corm damage data and assessments done on tagged suckers after *Beauveria bassiana* application.
- b) Soil analysis: for processing data on soil physical and chemical characteristics
- c) Weevils: for processing weevil infestation levels.

Data on soil analysis has already been compiled, while corm damage and weevil infectivity data are still being processed.



***Schedule for Beauveria bassiana application:***

| Farmer               | Application dates |          |          |          |          |          |         |          |
|----------------------|-------------------|----------|----------|----------|----------|----------|---------|----------|
| Phase I              | First             | Second   | Third    | Fourth   | Fifth    | Six      | Seventh | Eighth   |
| Mr. Kasozi Deo       | 3/07/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Male John        | 3/07/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Ssemenda Dan     | 3/07/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Kakugga Paulo    | 3/07/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Mayanja Lawrence | 3/07/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Phase II             | First             | Second   | Third    | Fourth   | Fifth    | Six      | Seventh | Eighth   |
| Mr. Kaddu Hussein    | 18/8/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mrs. Nakanjako       | 18/8/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Sseruwu Muhammad | 18/8/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Mubiru Muhammad  | 18/8/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |
| Mr. Kimala Hassan    | 18/8/03           | 30/10/03 | 30/01/04 | 30/04/04 | 30/07/04 | 30/10/04 | 30/1/05 | 30/04/05 |

**Plan for data analysis**

Data on corm damage, weevil infestation, and bunch weight will be subjected to analysis of variance using the SAS software package to compare treatments. Below is the expected ANOVA table.

| Source of Variation | Degree of freedom |
|---------------------|-------------------|
| Blocks              | 9                 |
| Treatment           | 2                 |
| Residual            | 18                |
| Total               | 29                |

**2. Sample data sheets**

a) Data sheet for corm damage assessment




| Farmer | Treatment | Plant No. | Corm damage |           | Corm damage (%) |       |
|--------|-----------|-----------|-------------|-----------|-----------------|-------|
|        |           |           | Entire (a)  | Inner (b) | Outer           | Inner |
|        |           |           |             |           |                 |       |
|        |           |           |             |           |                 |       |
|        |           |           |             |           |                 |       |

b) Data sheet for weevil infectivity and abundance

| Farmer | Treatment | Plant No. | Weevil abundance |      |
|--------|-----------|-----------|------------------|------|
|        |           |           | Dead             | Live |
|        |           |           |                  |      |
|        |           |           |                  |      |
|        |           |           |                  |      |
|        |           |           |                  |      |



**Data file names:**

|   |       |                        |                  |
|---|-------|------------------------|------------------|
|  Ma_Corm damage.xls        | 14 KB | Microsoft Excel Wor... | 04/03/2004 09:28 |
|  Ma_Soil analysis.xls      | 14 KB | Microsoft Excel Wor... | 04/03/2004 09:28 |
|  Ma_Weevil assessments.xls | 14 KB | Microsoft Excel Wor... | 04/03/2004 09:29 |

**Protocol file name:** *Protocol\_BbassianaEfficacy\_onfarm\_CK2.doc*

## Sample data sheets

### DFID INSECT PATHOLOGY (BANANA WEEVIL) TRIAL AT KARI a) DATA SHEET FOR CORM WEEVIL DAMAGE ASSESMENT

DATE.....

RECORDED BY .....

| REP | PLOT NO. | SPACING (m) | PLANT NO. | CORM DIAMETER (cm) |           | CORM DAMAGE (%) |       |
|-----|----------|-------------|-----------|--------------------|-----------|-----------------|-------|
|     |          |             |           | a (entire)         | b (inner) | OUTER           | INNER |
|     |          |             |           |                    |           |                 |       |
|     |          |             |           |                    |           |                 |       |
|     |          |             |           |                    |           |                 |       |
|     |          |             |           |                    |           |                 |       |
|     |          |             |           |                    |           |                 |       |
|     |          |             |           |                    |           |                 |       |

### b) BANANA WEEVIL ABUNDANCE ASSESSMENT RECORDS

DATE.....

RECORDED BY .....

| Plot No. | Plant No. | Weevils /mat | Comments | Plot No. | Plant No. | Weevils /mat | Comments |
|----------|-----------|--------------|----------|----------|-----------|--------------|----------|
|          |           |              |          |          |           |              |          |
|          |           |              |          |          |           |              |          |
|          |           |              |          |          |           |              |          |
|          |           |              |          |          |           |              |          |
|          |           |              |          |          |           |              |          |



### c) DATA SHEET FOR GROWTH PARAMETERS

RECORDED BY.....

| Reps | Plot No | Spacing<br>(m) | Plant<br>No. | Height<br>(mother)<br>(cm) | Girth<br>at 1m<br>(cm) | No. of<br>leaves<br>(mother) | No. of<br>leaves<br>(daughter ) | Flowering<br>date | Harvest<br>date | Bunch<br>Weight<br>(kgs) |
|------|---------|----------------|--------------|----------------------------|------------------------|------------------------------|---------------------------------|-------------------|-----------------|--------------------------|
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |
|      |         |                |              |                            |                        |                              |                                 |                   |                 |                          |

### References

Nankina, M.C. 1999. Characterization of entomopathogenic fungi and evaluation of delivery systems of *Beauveria bassiana* against the banana weevil, *Cosmopolites sordidus*. Ph.D Thesis, University of Reading, UK. 277pp.

Groden, E., and Dunn, T. 1996. Germination, host infection and survival of *Beauveria bassiana* conidia in natural soils. In: Proceedings of International Workshop on Microbial Control of Soil Dwelling pests. Jackson, T.A., and Glare, T.R. (Eds.), pp. 137-145. AgResearch, New Zealand

Ignoffo, C. M., D. L. Hostetter, P. P. Sikorowski, G. Sutter, and W. M. Brooks. 1977. Inactivation of representative species of entomopathogenic viruses, a bacterium, fungus and protozoan by an ultraviolet light source. *Environmental Entomology*, 6: 411-415.

Gold, C.S., Pena, J.E., and Karamura, E.B. 2001. Biology and integrated pest management for the banana weevil *Cosmopolites sordidus* (Germar) (Coleoptera: Curculionidae). Integrated Pest Management Reviews. 6: 79-155.



## **Descriptions Of DataFiles – from experiments done at CABI Nairobi**

### **Production of *Beauveria bassiana* for the management of banana weevil**

CAB International Africa Regional Centre

The experiments described here focused on the screening of waste, available and cheap solid substrates for the mass production of *Beauveria bassiana*. These form part of the activities of the project ‘Integrated Pest Management (IPM) of the banana weevil, *Cosmopolites sordidus* in Uganda’. The experiments were carried out sequentially because of the availability of waste solid substrates at the time of trials setting.

**Experiment 1:** Production of *B. bassiana* aerial conidia on bagasse substrate subjected to different water contents

The objective was to determine the potential and water content of bagasse for the production of aerial conidia of *B. bassiana*.

#### **Materials and Methods**

A liquid-solid phase technique was used for the production of *B. bassiana* aerial conidia. The liquid phase was to provide active growing mycelia and blastospores, while the solid phase was to provide dry aerial conidia. The two phases were prepared and inoculated as follows:

##### **Liquid phase**

A liquid medium was prepared by boiling 20g of sucrose and 20g of brewer’s yeast in one litre of water. The resulting broth was homogenized using a cooking wiring blender at medium speed for one minute. About 75 ml of the homogenized broth was poured into 250 ml Erlenmeyer flasks. The flasks were plugged with cotton wool wrapped with aluminium foil. The flasks were then autoclaved at 121°C, 120 kPa for 40 minutes.

Pure conidia of *B. bassiana* cultured on agar slant, was suspended in sterile distilled water (SDW) containing 0.05% Tween 80. The conidia concentration in the suspension was adjusted to  $10^7$  conidia/ml and used to inoculate the liquid medium in the Erlenmeyer flasks prepared as described above. One ml of the adjusted conidia suspension was used to inoculate 75 ml in the Erlenmeyer flask. The inoculated flasks were incubated on a rotary shaker for 3 days at 150 rpm for hyphae and blastospore biomass production. The hyphae and blastospore biomass was used to inoculate the solid substrates.

##### **Solid phase**

Bagasse, a waste product was collected from Chemilil sugar factory, in Nyanza Province, and used as a solid substrate in the production system.

The solid substrates were prepared as follow and represent the different treatments in the experiment:

1. 100 ml of bagasse + 0% water (w/v),
2. 100 ml of bagasse + 25% water,
3. 100 ml of bagasse + 50% water

The substrates were placed in heat resistant plastic bags bought in local market in Kenya. The plastic bags with the substrates were autoclaved at 121°C, 120 kPa for 40 minutes. The



autoclaved substrates were inoculated with 15 ml of hyphae and blastospores suspension and then placed in plastic bowls covered with lids. The plastic bowls were kept closed for 7 days. The plastic bowls of 14 cm diameter and 15 cm deep were bought at the Village Market in Nairobi. Three small holes of 3.5 cm diameter on the side of the bowls were made for the aeration and drying of the solid substrate and conidia. The holes were closed with cotton wool during the incubation period. The bowls were placed in a room in which temperature fluctuated between 24 to 26°C. After 7 days incubation the bowls were opened for drying of the sporulated substrates. The substrates were dried for 21 days at room temperature (24 - 26°C) for aerial conidia extraction.

### **Extraction:**

In each plastic bowl, 200 ml of SDW plus 0.05% Tween80 was added to the solid substrate. The bowl was gently shaken to dislodge all the aerial conidia on the substrate. The resulting suspension was sieved (106 µm mesh) and, thereafter, diluted for spore counting and viability test.

Data were collected 21 days after substrate incubation on:

- Number of conidia per ml of solid substrate,
- Percentage of conidial viability

### **Experiment 2: Evaluation of solid substrates for *Beauveria bassiana* aerial conidia production**

The objective of the experiment was to compare the potential of three solid substrates for the mass production of *B. bassiana*

### **Materials and Methods**

The production technique used in the experiment was similar to that used in experiment 1. 'Machicha' a waste product collected from the local 'busaa' brewery, bagasse a waste product from Chemilil sugar factory, and rice husk were locally collected and used to carry out the experiment. Rice grains were also used as a standard substrate (control) in the experiment. The rice grains were bought from a supermarket (village Market) in Nairobi. The solid substrates were treated as follows prior to autoclaving:

1. Bagasse washed and dried
2. 'Machicha' washed and dried
3. Machicha' washed and non-dried
4. Rice husks washed
5. Rice grains steamed

The solid substrates were put into plastic bags bought at the local market, and autoclaved at 121°C, 120 kPa for 40 minutes. The autoclaved substrates were inoculated with a liquid medium prepared as described in experiment 1. The inoculated substrates were maintained in the plastic bags for 7 days after inoculation. The plastic bags were then opened to dry the sporulated substrates for 21 days. The treatments were replicate 4 times and 100g of substrate was used per replicate.

Data were taken 21 days after bags were opened on:

- Number of conidia per gram of solid substrate,
- Percentage of germinated conidia



### **Experiment 3: Influence of moisture content in ‘machicha’ on the production of *B. bassiana***

The objective in this experiment was to determine the effect of moisture content of ‘machicha’ on the production of aerial conidia of *B. bassiana*.

#### **Materials and Methods**

The liquid and solid phase technique was used as described in experiment 1. The solid substrates were inoculated with the liquid medium. The plastic bags were closed for 7 days and then opened for drying the sporulated substrates. The substrates were dried at room temperatures (20 – 28°C). The treatments in the experiment were replicated 4 times, and were as follow:

1. Unwashed ‘machicha’ plus 25% water (w/v) (UWM25)
2. Unwashed ‘machicha’ plus 50% water (UWM50)
3. Unwashed ‘machicha’ plus 75% water (UWM75)
4. Unwashed ‘machicha’ plus 100% water (UWM100)
5. Washed ‘machicha’ plus 100% water (WM100)
6. Washed ‘machicha’ and then dried (WMD)
7. Unwashed ‘machicha’ (UWM)
8. Rice grains steamed (RGS)

Data were collected during the drying period, and at weekly intervals on:

Number of conidia per gram of substrate

Conidia viability

### **Experiment 4: The potential of various solid substrates for *B. bassiana* production (1)**

#### **Materials and Methods**

The liquid-solid phase technique as described in experiment 1 was used for the *B. bassiana* production on the various solid substrates tested. The solid substrates were moistened with tap water at a rate of 100% water (w/v) except the rice grains which were moistened with 30% water and steamed prior to autoclaving. The solid substrates tested were as follow:

1. ‘Machicha’ (MA)
2. Coffee husks and broken coffee pulp (CHP)
3. Coffee husks (CH)
4. Cotton seed cake (CSC)
5. Sunflower cake (SFC)
6. Rice grains steamed (RGS)

The solid substrates were autoclaved in plastic bags. Four replicates of 100 grams of each solid substrate were treated with tap water as described above and autoclaved at 121°C, 120 kPa for 40 minutes. The autoclaved substrates were left to cool at room temperature (25 – 28°C) for 2 hours and then inoculated with a liquid substrate of *B. bassiana* blastospores and hyphae prepared as described in experiment 1. The inoculated solid substrates were incubated in plastic bowls (diameter = 20.5 cm and depth = 11 cm) with 4 side holes (diameter = 2.5 cm) closed with non-absorbent cottonwood and incubated in room (25-28°C). The plastic bowls were closed for 7 days and then opened and the cottonwood over the holes removed to dry the sporulated substrates. The substrates were dried for 42 days, and data were taken six times at weekly intervals on:

- Number of conidia per gram of substrate
- Conidial viability.



### **Experiment 5: The potential of various solid substrates for *B. bassiana* production (2)**

#### **Materials and Methods**

Liquid medium and solid substrates were prepared as described in experiment 4. The following solid substrates were tested for their potential to sustain the growth of *B. bassiana*:

1. 'Machicha' (MA)
2. Coffee husk and broken coffee pulp (CHP)
3. Washed coffee husk and broken coffee pulp (WCHP)
4. Cotton seed cake (CSC)
5. Rice grains steamed (RGS)

The drying period of the substrates was the same as described in experiment 4.

### **Experiment 6: The potential of different Machicha based on method of brewing on Bb production (1)**

#### **Materials and Methods**

Liquid medium and solid substrates were prepared as described in experiment 4. The following solid substrates were tested for their potential to sustain the growth of *B. bassiana*:

- 1 = Rice
- 2 = Machicha 2
- 3 = Machicha 3
- 4 = Machicha 4

The drying period of the substrates was the same as described in experiment 4.

Data collected: Number of conidia per g of substrate and viability (germination)

### **Experiment 7: The potential of different Machicha based on method of brewing on Bb production (2)**

Liquid medium and solid substrates were prepared as described above. The following solid substrates were tested for their potential to sustain the growth of *B. bassiana*:

- 1 = Rice
- 2 = Machicha 5
- 3 = Machicha 6
- 4 = Machicha 8

The drying period of the substrates was the same as described above.

Data collected: Number of conidia per g of substrate and viability (germination)

### **Experiment 8: Assessing the different sizes of pumice on supporting Bb growth**

Liquid medium and solid substrates were prepared as described above. The following solid substrates were tested for their potential to sustain the growth of *B. bassiana*:

- 1 = Rice
- 2 = Large pumice particle (



- 3 = Medium pumice particle (
- 4 = Small pumice particles (
- 5 = Fine pumice particles (0.6 mm diameter

The incubation and drying periods of the substrates were 7 and 35 days respectively

Data collected: Number of conidia per g of substrate and viability (germination)

**Experiment 9:** Comparing the yield of Bb spores produced on different substrates (Rice, Machicha and Maize) (1)

Liquid medium and solid substrates were prepared as described above. The following solid substrates were tested for their potential to sustain the growth of *B. bassiana*:

- 1 = Rice;
- 2 = Machicha;
- 3 = Maize

The incubation period of the substrates was 14 days.

Data collected: Number of conidia per g of substrate and viability (germination)

**Experiment 10:** Comparing the viability of Bb spores raised in three different substrates (Rice, Machicha and Maize) (2)

Liquid medium and solid substrates were prepared as described above. The following solid substrates were tested for their potential to sustain the growth of *B. bassiana*:

- 1 = Rice;
- 2 = Machicha;
- 3 = Maize

The incubation period of the substrates was 14 days.

Data collected: Number of conidia per g of substrate and viability (germination)

Used to produce spores for the subsequent experiments

**Experiment 11: Assessment of the survival of Bb from different solid substrates at different temperatures** (9 data sets entered ongoing)

The spore powder used for the experiments were produced on:

- 1 = Rice;
- 2 = Machicha;
- 3 = Maize

0.001g of spore powder suspended in 9 ml of 0.05% of Tween water. 200ml of suspension plated on a 9 cm Petri dish with PDA medium incubated for 16-24 hours before observation.

1.0g of spore powder placed in each bijou bottle. 0.05g of on non-indicating Silica gel in half the bottles.



Temperatures:      -5<sup>0</sup>C (Freeze)  
                             4<sup>0</sup>C (Fridge)  
                             15<sup>0</sup>C (Incubator)  
                             25<sup>0</sup>C (Incubator)

The counts of germinating and non-germinating spores recorded after 16-24 hours.

### **On going experiments**

**Experiment 11:** Assessment of the survival of Bb from different solid substrates at different temperatures (**10 data sets**)

As above

**Experiment 12:** Assessment of different materials for packaging and storage of Bb under different temperature regimes (**4 data sets**)

The spore powder used for the experiment was produced on rice;

0.02g of spore powder suspended in 9 ml of 0.05% of Tween water. 200ml of suspension plated on a 9 cm Petri dish with PDA medium incubated for 16-24 hours before observation.

Packaging materials:

Coffee tins (200g)  
Metalised paper (sachet)  
Clear polythene (sachet)  
Dark polythene (sachet) and  
Aluminium foil (sachet)

1.0g of spore powder in each packaging material.

Temperatures:  
                             4<sup>0</sup>C (Fridge)  
                             15<sup>0</sup>C (Incubator)  
                             25<sup>0</sup>C (Incubator)

Fortnightly by taking 0.001g of spore powder suspended in 9ml of Tween water then plated on PDA .The counts of germinating and non-germinating spores recorded after 16-24 hours.

**Experiment 13:** Evaluation of the stability of Bb spores produced on rice under different temperature regimes and light conditions (**3 data sets**)

1g of spore powder produced on rice in bijou bottles

Temperatures  
                             4<sup>0</sup>C (Fridge)  
                             15<sup>0</sup>C (Incubator)  
                             25<sup>0</sup>C (Incubator)



Exposed to continuous light or darkness

Fortnightly by taking 0.001g of spore powder suspended in 9ml of Tween water then plated on PDA. The counts of germinating and non-germinating spores recorded after 16-24 hours.

## **SUMMARY: LIST OF EXPERIMENTS IN THE BANANA WEEVIL PROJECT**

### **Completed and data available**

1. Production of Bb aerial conidia on bagasse substrate subjected to different water contents
2. Evaluation of solid substrates for Bb aerial production
3. Influence of water quantity in Machicha on the Bb production
4. The potential of various solid substrates for Bb production (1)
5. The potential of various solid substrates for Bb production (2)
6. The potential of different Machicha based on method of brewing on Bb production (1)
7. The potential of different Machicha based on method of brewing on Bb production (2)
8. Assessing the different sizes of pumice on supporting Bb growth
9. Comparing the yield of Bb spores produced on different substrates (Rice, Machicha and Maize) (1)
10. Comparing the viability of Bb spores raised in three different substrates (Rice, Machicha and Maize) (2)
11. Assessment of the survival of Bb from different solid substrates at different temperatures (10 data sets entered **ongoing**)

### **On going experiments**

1. Assessment of the survival of Bb from different solid substrates at different temperatures (**10 data sets**)
2. Assessment of different materials for packaging and storage of Bb under different temperature regimes (**4 data sets**)
3. Evaluation of the stability of Bb spores produced on rice under different temperature regimes and light conditions (**3 data sets**)



**BACK TO OFFICE REPORT FROM ATTENDING A SHORT-TERM  
TRAINING PROGRAMME AT THE STATISTICAL SERVICES  
CENTER THE UNIVERSITY OF READING UK  
13<sup>th</sup> OCTOBER TO 7<sup>th</sup> NOVEMBER 2003**

**BY YUSUF MULUMBA**

**Biometrics Unit, Kawanda Agricultural Research Institute**

**Summary of the training**

My training Programme was 4 weeks long from the 13<sup>th</sup> October 2003 to 7<sup>th</sup> November 2003. The first week I attended a course on General Linear Models (GLM) and in the second week was on Analysis of Random Effects Models Using SAS PROC Mixed. The third week of training was on Research Data Management. During which we were shown how to design and develop Microsoft's Access databases to manage datasets generated from the research process. The 4<sup>th</sup> week was spent exploring the CPP data sets and working on my thesis as well.

**1. Introduction**

The University of Reading received a contract from the Crop Protection Programme (CPP) of the Department for International Development (DFID) for the research project R8301/ZA0565 titled '**Archiving data from integrated pest and disease management projects within the Uganda National Banana Research Programme**'.

This is for work to be done in collaboration with the Banana Research Programme (NBRP) of the National Agricultural Research Organisation (NARO). NARO therefore received a sub-contract by the University of Reading for their contribution to this project.

The National programme's effective involvement required short-term training at the University of Reading for two staff members i.e. myself and Allan Rwakatungu from the Biometrics unit at Kawanda Agricultural Research Institute (KARI). My own programme covered a 4-week period. The overall objectives of the training were:

- Improve on the statistical knowledge and practice
- Improve on the management of research data generated within the banana programme

Further details relating to this training programme are given in Annex 1.



## **2. Training courses in Statistics and Data management**

### *2.1 Training course on General Linear Models*

I attended a course on USING SAS PROC GLM; this is a procedure in SAS that uses the method of least squares to fit general linear models, for example simple and multiple linear regression models and general analysis of variance models involving balanced and unbalanced data.

This course lasted for two days (13<sup>th</sup> to 14<sup>th</sup> October) and covered the following topics.

- The general linear Model and an introduction to SAS PROC GLM
- Non-orthogonal data structures
- Models with factors and variates
- Estimability
- Use of Contrasts
- The nature of the four types of sum of squares
- Estimating functions

This was achieved by the numerous practical sessions we had with investigators who help in interpreting the SAS outputs. At the end of the course we were awarded the certificates of attendance. The teaching staffs for this course were Dr. Savitri Abeyasekera and Mr. James Gallagher.

### *2.2 Training course on Analysis of Random Effects Models Using SAS PROC Mixed*

On 15<sup>th</sup> to 17<sup>th</sup> October 2003 we were introduced to using SAS PROC MIXED and this lasted for three days. This course was on fitting mixed i.e. models with both fixed and random effects and how such models may be fitted using the MIXED procedure in SAS. Such models arise when treatments are a random selection from a wider group and when data are collected from a multi-strata structure with different levels variability.

The teaching staffs for this course were Dr. Savitri Abeyasekera, Mr. James Gallagher, Mrs. Eleanor Allan and Dr. Mike Patefield. The course covered the following topics.

On 15<sup>th</sup> October 2003

- Introduction: Review of Linear Models for Fixed Effects
- Random Effects and Variance Components
- Introduction to PROC MIXED
- Non-hierarchical Mixed Effects Models

On 16<sup>th</sup> October 2003

- Simple Hierarchical Designs
- Mixed Effects Modelling and REML
- Estimating Fixed Effects
- Cross-over Designs

On 17<sup>th</sup> October 2003

- Using Inter- and Intra-subject Information in Cross-over Studies
- Generalised Linear Mixed Models
- Repeated Measurements



### *2.3 Training course on Research data management*

During the second week of my stay, I attended the course on RESEARCH DATA MANAGEMENT from 20<sup>th</sup> to 22<sup>nd</sup> October 2003. This course was necessary because within the National Banana Research Programme, data of complexity are generated and the current use of spreadsheets like Excel has limitations as a data management tool.

During the course, we learned many data management concepts, and had practical work mainly using examples from surveys and experimental data. The course presenter was Mrs. Cathy Garlick. The timetable for the programme appears in Annex 2. In summary the following areas were covered.

On 20<sup>th</sup> October 2003:-We had data modelling, data concepts, database structure, E-R diagrams, creation of relationships, tables, field properties, primary keys, referential integrity, and an introduction to Access, and linking/exporting data from Excel to Access.

On 21<sup>st</sup> October 2003: - We had data querying, the query design grid, setting simple criteria, complex multiple criteria, queries based on several tables, queries for data checking, parameter queries, summarising data, queries to alter the data and SQL

On 22<sup>nd</sup> October 2003: - We covered topics on building the user interface, form design, sub-form, properties of form and form sections, linking forms using command buttons, VBA code for event procedures, designing a menu form and setting database options.

### **3. Further work on research data management**

On 23<sup>rd</sup> and 24<sup>th</sup> October 2003 we consolidated on learning activities of the previous 3 days by further related work. In particular Allan Rwakatungu and I discussed how the data management concepts would fit the data generated at the NBRP (Uganda), using the data from one of the CPP programme projects.

First on 23<sup>rd</sup> October 2003 I made a brief presentation to outline the kind of data that was generated using the IPM trials. Dr. Savitri and another senior statistician within SSC namely Mr. Carlos Barahona and Allan Rwakatungu attended this presentation.

The presentation covered the different levels at which information were available and outlined details of data that were generally collected at these different levels. Most Banana research projects have project details at the project level and information at sub levels as follows.

- Districts
- Parishes
- Villages
- Farmers
- Trials (on station and on farm)
- Plant level and plot level e.g. flowering, yield.
- Disease assessment.

Examples were given of the type of data collected at each of these levels.



After the presentation Carlos suggested that for experimental data we should use ICRAF's data logbook. He noted that since most of the data from the Banana Programme was managed in Excel files, logbook would be an easier way to transfer data to MS Access. That's what logbook does; it moves data from MS Excel to MS Access. But to do this, data in the Excel sheets must be logbook compliant; in other words, it should be entered in Excel in a predefined format. Details of logbook are in Annex 3. Allan and I agreed that it was good idea, and agreed to try and adopt logbook, firstly to datasets from the IPM trial and then encourage scientists to take it up in future. Carlos then promised to bring us some literature from the logbook manual being written by Cathy Garlick of the SSC so we could understand the concepts of the logbook. We then set as our next task of designing of an Access database for a social economic survey carried out in one of the CPP projects.

Allan and I continued from where we had stopped before, designing and developing an Access database for the CPP social economic survey. Later, we had a discussion on logbook with Carlos, trying to understand how we could format Excel data sheets to make them "Logbook compatible". Allan then made a presentation on what he and I had been doing during the week. Dr Savitri, Mr Barahona and Mr Dale attended. Details of the presentation are in Annex 4.

#### **4. Further training on General Linear models and Binary Data Analysis**

On 27<sup>th</sup> I spent time working through exercises provided by Savitri on Linear Models and we had a discussion on my work. Later during the day Allan and I continued designing and developing an Access database for the CPP social economic survey with the help of Ian Dale.

On 28<sup>th</sup> and 29<sup>th</sup>, I went through course notes of a one-day SSC course on Analysis of Binary and Categorical Data supervised by Savitri. The topics covered were:

- Chi-square Tests for 2x2 tables
- Chi-square Tests for r x c tables
- Introduction to Logistic Modelling
- Logistic Regression Models with Covariates

Later I discussed with Savitri the points that I could not understand alone, and also discussed many other related issues, how to explain to a scientist the exact meaning of Test of significance. This was important to me as I'm always faced with a lot of data that is Binary and Categorical

Later on 29<sup>th</sup> October 2003 Savitri took Allan and me to see Dr Simon Gowen, advisor to CPP. Simon gave us a brief "lecture" on banana breeding. Allan and I then told him what we had been learning for the past two weeks.

During the period of 30<sup>th</sup> October 2003 Savitri went through my dissertation and advised me to be more focused on how to achieve each of the objectives from the data I've got. She gave me notes on Linear Models and a hand out on Quantitative Research Methods in the Social Sciences to read about Causality. The concept she was of the view I could leave it out for my dissertation.

In the afternoon, Allan and I discussed procedures for the flow of data from planning stages to data collection and computerisation and details are given under Annex 5.

On 31<sup>st</sup> October 2003 Savitri discussed with me model selection procedures. I then attended Savitri's lecture to Reading University MSc students about Model selection strategies. This was of help to me because it's the kind of challenge I often face at work with Banana



programme. Later in the day I went through the questionnaires of Kisekka baseline survey trying to identify which variables could help me perfect my modelling for my thesis.

## **5. Continuation of data analysis work related to the IPM project**

On Monday 3<sup>rd</sup> November 2003, I did some work on my MSC thesis basing on the discussions with Savitri on Friday 31<sup>st</sup> October. Later during the day we spent the afternoon working on the IPM data sets. Savitri showed me how we can finally design each of the data sets to fit into the NBRP achieve.

The following three days I went through the rest of the IPM data sets making sure that within each workbook where data is there is information relating to the data. This I did with Savitri checking on me from time to time for any clarifications.

On Friday 7<sup>th</sup> November 2003, in the morning Savitri looked at what I did on the IPM trials and advised for the rest of the day to focus on my MSC thesis. Later in the afternoon we discussed my MSC work and Savitri gave me a guiding document to modern modelling which she advised me to get a copy.

Personally, I found the courses helpful in that they added to my statistical knowledge and practice. The discussions I had teaching staff enhanced my thing as well people like Savitri and Ian Dale.

## **Acknowledgements**

First and foremost I would like to acknowledge the Department for International Development (DFID) for making funds available for this training. I also would like to acknowledge the National Banana Research Programme for allowing me to come for this training. Dr Savitri Abeyasekera is acknowledged .She made arrangements for this training and everything from getting invitation letters to arriving at Heathrow airport and finally to Reading, my stay in Reading, the classes and extra curricular activities all went smoothly because of her. Ms Cathy Garlick, thank you .The course on data management was fantastic. I also acknowledge Lorna Turner; everything went like clock work as she took care of things for me. Thank you to Dr. Ian Wilson, Mr. Ian Dale Dr Roger Stern, Carlos Barahona, they were all a great help.



## ***Annex 1:***

### **Training Programme in Reading for Yusuf Mulumba and Allan Rwakatungu from the Biometrics Unit of the Uganda National Banana Research Programme (UNBRP)**

#### **Yusuf Mulumba (4 weeks from 12 October to 9 November)**

**Week 1** (13-17 October) – Attendance at PROC GLM and PROC MIXED courses

**Week 2** (20-25 October) – Attendance at Research Data Management course (mainly ACCESS), followed by practical work involving setting up the format (together with Allan) for a relational data base for the Banana Research Programme activities. Cathy to supervise (1 day of help over 2 days).

**Week 3** (27-31 October) – Attendance at the 3-day Modern Regression Modelling course (if it runs), followed by data analysis work using IPM data. Savitri to supervise. If regression course does not run, he will work (for 2 days) through the material of the 1-day Binary and Categorical Data analysis course, with help from Savitri, followed by an attempt to apply this knowledge to the IPM data.

**Week 4** (3-7 November) – Continuation of data analysis work related to the IPM project, again supervised by Savitri.

## ***Annex 2:***

### **Research data management timetable (20 – 22 October 2003)**

#### **Day 1 – Data Modelling**

|               |                                |  |
|---------------|--------------------------------|--|
| 8.45 - 9.00   | <i>Registration and Coffee</i> |  |
| 9.00 – 11.00  | <b>Session 1:</b>              | <b>Data Modelling</b><br><i>The logical structure of the data including links between data, E-R diagrams, key fields.</i>  |
| 11.00 - 11.15 | <i>Coffee</i>                  |  |
| 11.15 - 12.45 | <b>Session 2:</b>              | <b>Introduction to Access</b><br><i>Creating tables in Access; setting field properties; etc.</i>  |
| 12.45 - 2.00  | <i>Lunch</i>                   |  |
| 2.00 - 2.30   | <b>Session 2 cont.</b>         |  |
| 2.30 - 3.30   | <b>Session 3:</b>              | <b>Database Design</b><br><i>Using Access to build the physical structure based on the logical structure of the data; setting relationships in Access and validating relationships with referential integrity.</i> |
| 3.30 - 3.45   | <i>Tea</i>                     |  |
| 3.45 - 4.45   | <b>Session 3 cont.</b>         |  |
| 4.45 - 5.00   | <i>Summary of day</i>          |  |
| 6.00          | <i>Dinner</i>                  |  |

#### **Day 2 – Data Querying**

|               |                   |  |
|---------------|-------------------|--|
| 9.00 – 11.00  | <b>Session 1:</b> | <b>Quick Searches &amp; Filters</b><br><i>Finding records, filters, sorting data, advanced filters, saving filters as queries.</i>               |
| 11.00 - 11.15 | <i>Coffee</i>     |  |
| 11.15 - 12.45 | <b>Session 2:</b> | <b>Query Design</b><br><i>Using the query design grid to create select queries in Access; using data from several tables; calculated fields.</i> |



|              |                        |   |
|--------------|------------------------|---|
| 12.45 - 2.00 | <i>Lunch</i>           |   |
| 2.00 - 2.30  | <b>Session 2 cont.</b> |   |
| 2.30 - 3.30  | <b>Session 3:</b>      | <b>Advanced Queries</b><br><i>Action queries to change the data; crosstab queries; query wizards; asking the question in the right way.</i> |
| 3.30 - 3.45  | <i>Tea</i>             |   |
| 3.45 - 4.45  | <b>Session 3 cont.</b> |   |
| 4.45 - 5.00  | Summary of day         |   |

### Day 3 – Building the User Interface

|               |                        |  |
|---------------|------------------------|--|
| 9.00 – 11.00  | <b>Session 1:</b>      | <b>Form Design</b><br><i>Simple form design in Access; controls on the forms and their properties; sub-forms.</i>    |
| 11.00 - 11.15 | <i>Coffee</i>          |  |
| 11.15 - 12.45 | <b>Session 2:</b>      | <b>Event Procedures</b><br><i>When Events happen. Using Event procedures to link forms, automatic skip and fill.</i> |
| 12.45 - 2.00  | <i>Lunch</i>           |  |
| 2.00 - 2.30   | <b>Session 2 cont.</b> |  |
| 2.30 - 3.30   | <b>Session 3:</b>      | <b>Controlling the user view</b><br><i>Setting database options to control what the user sees.</i>                   |
| 3.30 - 3.45   | <i>Tea</i>             |  |
| 3.45 - 4.45   | <b>Session 3 cont.</b> |  |
| 4.45 - 5.00   | Summary of day         |  |

Course Presenter: Cathy Garlick

## Annex 3.

### About ICRAF's data logbook

Peter Muraya, computer programmer with ICRAF in Kenya realized that most scientists use Excel to manage their datasets, but Access is better at managing datasets. Rather than convert scientists to using Access, Peter developed an application where scientists continue to use Excel but the data is stored in an Access database. This application is called Data logbook.

However, for logbook to successfully move data into Access from excel it must be entered in a pre defined format hence the term logbook compliance. Titles have to be entered in a certain area of the spreadsheet, variable labels in another area and the data in another area. Logbook also has strict naming conventions

Figure 1 illustrates what an logbook compliance spreadsheet would look like..

|            |                  |                  |                  |
|------------|------------------|------------------|------------------|
| title      |                  |                  |                  |
| data       | Unit of measure  | Unit of measure  | Unit of measure  |
| Variable s | Variable header1 | Variable header1 | Variable header1 |
|            | data             | data             | data             |
|            | data             | data             | data             |

At the moment, Cathy Garlick is writing the manual for logbook.



Logbook is an exciting prospect for the NBRP, as it would go a long way in improving the ways in which we manage our data. Logbook was designed with scientist like those of NBRP in mind.

Yusuf and I agreed to try and make some experimental data of the NBRP logbook complaint. Logbook, we were made to understand can organize both social economic survey kind of data and experimental data but development of this software at the moment has been geared mainly at experimental data than at survey data so is better suited for the latter. Making NBRP datasets logbook compliant is a win win situation for the NBRP, because even if it never gets to use the logbook application its datasets will be uniformly organized which in itself is a very big step towards better data management.

## ***Annex 4.***

### **Rwakatungu Allan s presentation**

**Title:** Research Data Management

Section 1: What we have learnt and how we have applied it

- Data modelling
- Database design
- Form design
- Querying
- Event procedures

Section 2. Were we go from here

- Encourage NBRP to adopt logbook for experimental data
- Make some existing datasets logbook compliant
- Make new datasets logbook complaint
- Design from scratch Access databases for surveys

Section 3. Challenges and bottlenecks

- More practice on database design and development needed by Yusuf and I
- Scientist need to made to realize the importance of data management in there research process and give it high priority

#### **Attendance:**

Dr Savitri Abayesekera

Mr.Carlos Baharona

Mr.Ian Dale

Mr.Mulumba Yusuf

Mr.Rwakatungu Allan



## ***Annex 5***

### **Procedures and Guidelines for managing research data within the National Banana Research Programme (Draft for discussion with NBRP staff)**

#### **Stages of data management**

- During planning of every experiment and survey, Biometrics' staff to be present and then everyone's roles defined.
- Scientist writes protocol. If changes are made to the protocol, it should be updated and a copy lodged with the Biometrics unit.
- After designing the data collection instrument, this should be passed to Biometrics unit before data collection for reviewing.
- The Biometrics unit in consultation with the scientists' sets up data entry forms/screen.
- In case it's not the Biometrics section to manage the data, then the unit should at least play an advisory role.
- Time should be allocated for a pilot survey as this will help in training the enumerators, data entrants and test the designed data entry screens to check if they are suitable.
- The scientist updates the final questionnaire or data entry sheet for an experiment, and gives a copy to the Biometrics unit for updating the data entry screens before data collection starts.
- The general protocol should be availed to Biometrics and it should include project overview, introduction, methods, and questionnaires.
- There should not be changes to the questionnaire after any data collection is made unless all the steps above are to be repeated. If many changes are found necessary, then the objectives should be reviewed to ensure the data is still consistent with the objectives.
- Organization of questionnaires from the field and checking answers are consistent.
- Office editing of experimental data collection sheets and editing/coding of survey questionnaires.
- Data entry supervised by the scientists in consultation with biometrics section.
- Storing of unedited or raw data files by the data manager.
- Editing/cleaning the computerised data by scientists before any attempt to analyse it.
- Archiving of final data files by scientist with copy passed to the Biometrics Unit.
- Create backups weekly if there are updates made.
- Guidelines prepared for setting out responsibility and procedures for storage, disposal of data files, protocols and reports.
- Milestones for data analysis and reporting.

#### **Challenges with the IPM trials**

- Training those to be involved at the beginning in a given study
- Some farmers becoming reluctant to reveal some information and dropping out of the trials due to death etc.
- Cleaning bits of data is time consuming so labouring
- Large volume of data sets generated
- Standard questionnaires that do not change within the study.
- Data stored in form of a database system for a particular experiment/survey but not as files.
- Creating backups regularly for on going experiments/surveys
- Proper documentation of studies.
- Timely reporting and writing papers.
- Archiving for reference and other users.

***Prepared by Yusuf Mulumba and Allan Rwakatungu, 30<sup>th</sup> October 2003***



## **Back to Office Report - Rwakatungu Allan Biometrics Unit, Kawanda Agricultural Research Institute**

### **Training at the Statistical Services Centre, University of Reading, UK 20th to 31st October 2003**

#### **Summary of the training**

My training Programme was 2 weeks long from the 20<sup>th</sup> October 2003 to 31<sup>st</sup> October 2003. The training programme timetable is in *Annex 1*.

The first week of training was on Research Data Management. This was a taught course, with 7 participants, during which we were shown how to design and develop Microsoft's Access databases to manage datasets generated from the research process.

The second week was spent exploring ways in which I could improve my skills in mapping data (Geographical Information Systems - GIS), and web design and development.

#### **Introduction**

The Statistical Service Centre (SSC) of the University of Reading received a contract from the Crop Protection Programme (CPP) of the Department for International Development (DFID) for the research project R8301/ZA0565 titled '**Archiving data from integrated pest and disease management projects within the Uganda National Banana Research Programme**'. This is for work to be done in collaboration with the Banana Research Programme (NBRP) of the National Agricultural Research Organisation (NARO). NARO was therefore sent a sub-contract by the University of Reading for their contribution to this project.

The National programme's effective involvement required a short-term training at the University of Reading for two staff members from the Biometrics unit of Kawanda Agricultural Research Institute (KARI), i.e. Mulumba Yusuf and myself.

#### **WEEK 1. Training course on Research Data Management**

In the first week, I attended the course on Research Data Management from 20<sup>th</sup> to 22<sup>nd</sup> October 2003. This course was necessary because within the National Banana Research Programme, data of complexity are generated and the current use of spreadsheets like Excel has limitations as a data management tool.

In the course, we learned many data management concepts, and had practical work mainly using examples from surveys and experimental data. The course presenter was Mrs. Cathy Garlick.

The following areas were covered:

1.1 *20th October 2003: - Data modelling.* In this session we were taught about the logical structure of data including links between data, E-R diagrams and key fields. We were then introduced to MS Access and taught how to create tables, set field properties etc. Later we were taught how to build the physical structure in Access based on the logical structure, setting relationships in Access and validating relationships with referential integrity

1.2 *21st October 2003: - Data Querying* The topics we covered here include doing quick searches and filters to find, filter and sort data using Access. We were introduced to the Access query design



grid, using it to create simple select queries, using it to select data from several tables and making calculated fields. We then went on to design advanced queries such as action queries that can change data and how to use query wizards.

1.3 22<sup>nd</sup> October 2003:- **Building the user interface** Here, we were taught how to design simple forms in Access, put controls on the forms and control properties and also how to apply sub forms. In addition we were taught how to use event procedures to link forms and do automatic skips and fills. We also learnt how to set up database options so we can control what the user sees.

The next two days were then spent consolidating what we had we learnt by applying it to datasets generated by the National Banana Research Organization.

1.4 23<sup>rd</sup> October 2003: - Yusuf and I tried to design a database for data generated from one of the IPM trials. We came up with a logical model identifying different variables from the experiment and how they were related. We then went on to design an Access database where we set up tables and relationships between the tables. Later on Yusuf made a presentation on what we had done with Dr. Savitri and another senior statistician within SSC, Mr. Carlos Barabona in attendance. Details of Yusuf's presentation are in Annex 2

After the presentation Carlos suggested that for experimental data we should use ICRAF's data logbook. He noted that since most of the data from the Banana Programme was managed in Excel files, logbook would be an easier way to transfer data to MS Access. That's what logbook does; it moves data from MS Excel to MS Access. But to do this, data in the Excel sheets must be logbook compliant; in other words, it should be entered in Excel in a predefined format. Details of logbook are in Annex 3. Yusuf and I agreed that it was good idea, and agreed to try and adopt logbook, firstly to datasets from the IPM trial and then encourage scientists to take it up in future. Carlos then promised to bring us some literature from the logbook manual being written by Cathy Garlick of the SSC so we could understand the concepts of the logbook. We then set as our next task of designing of an Access database for a social economic survey carried out in one of the CPP projects.

1.5 24<sup>th</sup> October 2003: - Yusuf and I continued from where we had stopped before, designing and developing an Access database for the CPP social economic survey. Later, we had a discussion on logbook with Carlos, trying to understand how we could format Excel data sheets to make them "Logbook compatible". I then made a presentation on what Yusuf and I had been doing during the week. Dr Savitri, Mr Barahona and Mr Dale attended. Details of the presentation are in Annex 4.

## **WEEK 2. Training in GIS, and Web design and development**

In the second week, with assistance from Ian Dale , I explored various Geographic Information Systems and ways in which I could improve the site I had built for the NBRP.

2.1 27<sup>th</sup> October 2003: -Ian introduced me to a wide range of GIS packages including DIVA and Microsoft Map (a simplified version of MapInfo that is built in to Excel). For details on these see Annex 5. Together, we explored how we could generate maps using these software's . He showed me various websites where these maps could be obtained. A list of these websites is in Annex 6.

2.2 28<sup>th</sup> October 2003: - Ian and I further explored GIS, and ways in which the National Banana Research Programme could apply it. Later, Ian had a look at the website I developed for the NBRP. We discovered that we could not view more than one page because the free web hosts at <http://www.brinkster.com> give limited bandwidth viewing to those who are hosting free of charge. Ian then gave me invaluable tips on how I could improve this website. He told how I could reduce the size of the web site files by decreasing on the picture sizes and reducing them in number so I could be miserly with bandwidth. He also showed me how I could relatively reference my web pages and related files. Previously I had absolute referenced the web pages and files which meant that when these files are transferred to another computer the links between pages and files had to be reset for it



to work properly. Ian gave me more tips on good web design “habits” like writing html, which is easy to edit and also keep in mind the wide audience of people that may visit the site.

*2.3 29<sup>th</sup> October 2003:* - This day was also spent learning about web development. Ian showed me how I could develop web forms that capture information entered by visitors to websites sending it to my email inbox or to a text file where the data would then be imported into a database. He taught how I could achieve this using perl script to write CGI applications that run at the web server and process the data from the form to my inbox. I did an exercise on this.

Later in the day Savitri took Yusuf and myself to see Dr Simon Gowen, advisor to CPP. Simon gave us a brief “lecture” on banana breeding. Yusuf and I then told him what we had been learning for the past two weeks.

*2.4 30<sup>th</sup> October 2003:*

The first half of the day, I continued with activities on web design and development. I did some practice, trying to edit cgi scripts on my own and using the FTP programme to move files from my client machine to the server after editing them, The remaining half day I had a discussion with Yusuf about procedures for the flow of data from planning stages to data collection to computerisation. Details of this discussion are in Annex 7.

*2.5 31<sup>st</sup> October 2003:*

This day was spent wrapping up my stay in Reading. I did some touches on this report, packed my study materials ,made backups of the computer files I had been using and got some freeware software that Carlos availed to me.

## **Acknowledgements**

First and foremost I would like to acknowledge the Department for International Development (DFID) for making funds available for this training. I also would like to acknowledge the National Banana Research Programme for allowing me to come for this training. Dr Savitri Abeyasekera is acknowledged. She made arrangements for this training and everything from getting invitation letters to arriving at Heathrow airport and finally to Reading, my stay in Reading, the classes and extra curricular activities all went smoothly because of her. I would also like to acknowledge Mr. Ian Dale, not only for giving me invaluable knowledge in GIS and web design but also for making my stay in Reading much more comfortable. Ms Cathy Garlick, thank you. The course on data management was fantastic. I also acknowledge Lorna Turner; everything went like clock work as she took care of things for me. Thank you also to Dr. Ian Wilson, Dr Roger Stern, Carlos Barahona, they were all a great help.



## ***Annex 1.***

### **Training Programme in Reading for Yusuf Mulumba and Rwakatungu Allan from the Biometrics Unit of the National Banana Research Programme (UNBRP)**

#### ***Week 1*** (20 – 24 October)

20-22 October: Attendance at Research Data Management course (mainly ACCESS).

23 & 24 October: Practical work involving setting up the format (together with Yusuf) for a relational data base for one or two of the activities within the Banana Research Programme activities.

#### ***Week 2 (27-31 October)***

27-31 October:

- (a) GIS facilities using Excel – in relation to specific examples of value to UNBRP
- (b) Setting up forms to update web-page information.
- (c) Improving the web-page set-up for UNBRP
- (d) Outlining procedures for data collection and management at NBRP (with Yusuf Mulumba)

## ***Annex 2.***

### **Yusuf presentation**

The presentation covered the different levels at which information were available and outlined details of data that were generally collected at these different levels. Most Banana research projects have project details at the project level and information at sub levels as follows.

- Districts
- Parishes
- Villages
- Farmers
- Trials (on station and on farm)
- Plant level and plot level e.g. flowering, yield.
- Disease assessment.

Examples were given of the type of data collected at each of these levels.

## ***Annex 3.***

### **About ICRAF's data logbook**

Peter Muraya, computer programmer with ICRAF in Kenya realized that most scientists use Excel to manage there datasets, but Access is better at managing datasets. Rather than convert scientists to using Access, Peter developed an application where scientists continue to use Excel but the data is stored in an Access database. This application is called Data logbook.

However, for logbook to successfully move data into Access from excel it must be entered in a pre defined format hence the term logbook compliance. Titles have to be entered in a certain area of the spreadsheet, variable labels in another area and the data in another area. Logbook also has strict naming conventions

Figure 1 illustrates what an logbook complaint spreadsheet would look like..

|            |                  |                  |                  |
|------------|------------------|------------------|------------------|
| title      |                  |                  |                  |
| data       | Unit of measure  | Unit of measure  | Unit of measure  |
| Variable s | Variable header1 | Variable header1 | Variable header1 |
|            | data             | data             | data             |
|            | data             | data             | data             |

At the moment, Cathy Garlick is writing the manual for logbook.



Logbook is an exciting prospect for the NBRP, as it would go a long way in improving the ways in which we manage our data. Logbook was designed with scientist like those of NBRP in mind.

Yusuf and I agreed to try and make some experimental data of the NBRP logbook complaint. Logbook, we were made to understand can organize both social economic survey kind of data and experimental data but development of this software at the moment has been geared mainly at experimental data than at survey data so is better suited for the latter. Making NBRP datasets logbook compliant is a win win situation for the NBRP, because even if it never gets to use the logbook application its datasets will be uniformly organized which in itself is a very big step towards better data management.

## ***Annex 4.***

### **Rwakatungu Allan s presentation**

**Title:** Research Data Management

Section 1: What we have learnt and how we have applied it

- Data modelling
- Database design
- Form design
- Querying
- Event procedures

Section 2. Were we go from here

- Encourage NBRP to adopt logbook for experimental data
- Make some existing datasets logbook compliant
- Make new datasets logbook complaint
- Design from scratch Access databases for surveys

Section 3. Challenges and bottlenecks

- More practice on database design and development needed by Yusuf and I
- Scientist need to made to realize the importance of data management in there research process and give it high priority

#### **Attendance:**

Dr Savitri Abayesekera

Mr.Carlos Baharona

Mr.Ian Dale

Mr.Mulumba Yusuf

Mr.Rwakatungu Allan

## ***Annex 5.***

### **DIVA GIS**

DIVA-GIS is a free (GIS) software

You can use it to make maps of species distribution data, and analyze these data using grids. DIVA-GIS was specifically developed for use with genebank data such as available through national or international genebank documentation systems and [SINGER](#).

With DIVA you can:



- Make maps of the sites where a plant or animal species was observed (and perhaps collected), or of characters of these observations;
- Make grid maps of the distribution of biological diversity (e.g., species richness; Shannon index); and identify areas that have complementary levels of diversity;
- Make maps of the sites where a plant or animal species was observed (and perhaps collected), or of characters of these observations;
- Extract climate data for accession points, and predict the presence of species, for the current climate or the climate of the future

### **Microsoft Map**

Microsoft Map displays geographical data and values in a map. Maps are created within Excel. Maps made with Microsoft Map can be copied and pasted into Microsoft Word, PowerPoint and FrontPage.

## **Annex 6.**

### **Useful websites**

| <b>Website</b>  | <b>Information at website</b> |
|---|-------------------------------|
| <a href="http://www.rdg.ac.uk">http://www.rdg.ac.uk</a>   | Reading University            |
| <a href="http://www.wcape.school.za/subject/CS/PHS/msmap/">http://www.wcape.school.za/subject/CS/PHS/msmap/</a>       | Microsoft map                 |
| <a href="http://www.cnr.berkeley.edu/~alyons/zm/mapping.html">http://www.cnr.berkeley.edu/~alyons/zm/mapping.html</a> | Microsoft map                 |
| <a href="http://riu.cip.cgiar.org/diva-gis/index.php">http://riu.cip.cgiar.org/diva-gis/index.php</a>                 | DIVA                          |
| <a href="http://www.w3.org/">http://www.w3.org/</a>   | WWW consortium                |
| <a href="http://www.anybrowser.org/campaign/">http://www.anybrowser.org/campaign/</a>                                 | Viewable any browser campaign |
| <a href="http://www.w3.org/MarkUp/Guide/">http://www.w3.org/MarkUp/Guide/</a>   | Writing good HTML guide       |
| <a href="http://www.scriptarchive.com/">http://www.scriptarchive.com/</a>   | Perl script archive           |
| <a href="http://www.depha.org/excel_mapping.asp">http://www.depha.org/excel_mapping.asp</a>                           | Excel mapping                 |
| <a href="http://www.lies.com">http://www.lies.com</a>   | Guide to perl script          |
| <a href="http://www.personal.rdg.ac.uk/~snsdale/icd.html">http://www.personal.rdg.ac.uk/~snsdale/icd.html</a>         | Ian Dales homepage            |

## **Annex 7.**

### **Procedures and Guidelines for managing research data within the National Banana Research Programme (Draft for discussion with NBRP staff)**

#### **Stages of data management**

- During planning of every experiment and survey, Biometrics' staff to be present and then everyone's roles defined.
- Scientist writes protocol. If changes are made to the protocol, it should be updated and a copy lodged with the Biometrics unit.
- After designing the data collection instrument, this should be passed to Biometrics unit before data collection for reviewing.
- The Biometrics unit in consultation with the scientists' sets up data entry forms/screen.
- In case it's not the Biometrics section to manage the data, then the unit should at least play an advisory role.
- Time should be allocated for a pilot survey as this will help in training the enumerators, data entrants and test the designed data entry screens to check if they are suitable.
- The scientist updates the final questionnaire or data entry sheet for an experiment, and gives a copy to the Biometrics unit for updating the data entry screens before data collection starts.
- The general protocol should be availed to Biometrics and it should include project overview, introduction, methods, and questionnaires.



- There should not be changes to the questionnaire after any data collection is made unless all the steps above are to be repeated. If many changes are found necessary, then the objectives should be reviewed to ensure the data is still consistent with the objectives.
- Organization of questionnaires from the field and checking answers are consistent.
- Office editing of experimental data collection sheets and editing/coding of survey questionnaires.
- Data entry supervised by the scientists in consultation with biometrics section.
- Storing of unedited or raw data files by the data manager.
- Editing/cleaning the computerised data by scientists before any attempt to analyse it.
- Archiving of final data files by scientist with copy passed to the Biometrics Unit.
- Create backups weekly if there are updates made.
- Guidelines prepared for setting out responsibility and procedures for storage, disposal of data files, protocols and reports.
- Milestones for data analysis and reporting.

### Challenges with the IPM trials

- Training those to be involved at the beginning in a given study
- Some farmers becoming reluctant to reveal some information and dropping out of the trials due to death etc.
- Cleaning bits of data is time consuming so labouring
- Large volume of data sets generated
- Standard questionnaires that do not change within the study.
- Data stored in form of a database system for a particular experiment/survey but not as files.
- Creating backups regularly for on going experiments/surveys
- Proper documentation of studies.
- Timely reporting and writing papers.
- Achieving for reference and other users.

*Prepared by Yusuf Mulumba and Allan Rwakatungu  
30<sup>th</sup> October 2003*

## Annex 8.

### Research data management timetable: 20 – 22 October 2003

#### Day 1 – Data Modelling

|               |                                |  |
|---------------|--------------------------------|--|
| 8.45 - 9.00   | <i>Registration and Coffee</i> |  |
| 9.00 – 11.00  | <b>Session 1:</b>              | <b>Data Modelling</b><br><i>The logical structure of the data including links between data, E-R diagrams, key fields.</i>  |
| 11.00 - 11.15 | <i>Coffee</i>                  |  |
| 11.15 - 12.45 | <b>Session 2:</b>              | <b>Introduction to Access</b><br><i>Creating tables in Access; setting field properties; etc.</i>  |
| 12.45 - 2.00  | <i>Lunch</i>                   |  |
| 2.00 - 2.30   | <b>Session 2 cont.</b>         |  |
| 2.30 - 3.30   | <b>Session 3:</b>              | <b>Database Design</b><br><i>Using Access to build the physical structure based on the logical structure of the data; setting relationships in Access and validating relationships with referential integrity.</i> |
| 3.30 - 3.45   | <i>Tea</i>                     |  |



|             |                        |
|-------------|------------------------|
| 3.45 - 4.45 | <b>Session 3 cont.</b> |
| 4.45 - 5.00 | Summary of day         |
| 6.00        | <i>Dinner</i>          |

## Day 2 – Data Querying

|               |                        |  |
|---------------|------------------------|--|
| 9.00 – 11.00  | <b>Session 1:</b>      | <b>Quick Searches &amp; Filters</b><br><i>Finding records, filters, sorting data, advanced filters, saving filters as queries.</i>               |
| 11.00 - 11.15 | <i>Coffee</i>          |  |
| 11.15 - 12.45 | <b>Session 2:</b>      | <b>Query Design</b><br><i>Using the query design grid to create select queries in Access; using data from several tables; calculated fields.</i> |
| 12.45 - 2.00  | <i>Lunch</i>           |  |
| 2.00 - 2.30   | <b>Session 2 cont.</b> |  |
| 2.30 - 3.30   | <b>Session 3:</b>      | <b>Advanced Queries</b><br><i>Action queries to change the data; crosstab queries; query wizards; asking the question in the right way.</i>      |
| 3.30 - 3.45   | <i>Tea</i>             |  |
| 3.45 - 4.45   | <b>Session 3 cont.</b> |  |
| 4.45 - 5.00   | Summary of day         |  |

## Day 3 – Building the User Interface

|               |                        |  |
|---------------|------------------------|--|
| 9.00 – 11.00  | <b>Session 1:</b>      | <b>Form Design</b><br><i>Simple form design in Access; controls on the forms and their properties; sub-forms.</i>    |
| 11.00 - 11.15 | <i>Coffee</i>          |  |
| 11.15 - 12.45 | <b>Session 2:</b>      | <b>Event Procedures</b><br><i>When Events happen. Using Event procedures to link forms, automatic skip and fill.</i> |
| 12.45 - 2.00  | <i>Lunch</i>           |  |
| 2.00 - 2.30   | <b>Session 2 cont.</b> |  |
| 2.30 - 3.30   | <b>Session 3:</b>      | <b>Controlling the user view</b><br><i>Setting database options to control what the user sees.</i>                   |
| 3.30 - 3.45   | <i>Tea</i>             |  |
| 3.45 - 4.45   | <b>Session 3 cont.</b> |  |
| 4.45 - 5.00   | Summary of day         |  |

Course Presenter: Cathy Garlick



## ***Annex 9.***

### **Useful contact from the Statistical Service Centre of the University of Reading**

| <b>Name</b>                         | <b>Position</b>        | <b>Email</b>   |
|-------------------------------------|------------------------|--|
| <a href="#">Eleanor Allan</a>       | Director               | <a href="mailto:e.f.allan@rdg.ac.uk">e.f.allan@rdg.ac.uk</a>         |
| <a href="#">Ian Wilson</a>          | Special Adviser        | <a href="mailto:i.m.wilson@rdg.ac.uk">i.m.wilson@rdg.ac.uk</a>       |
| <a href="#">Roger Stern</a>         | Chief Biometrician     | <a href="mailto:r.d.stern@rdg.ac.uk">r.d.stern@rdg.ac.uk</a>         |
| <a href="#">Savitri Abeyasekera</a> | Principal Statistician | <a href="mailto:s.abeyasekera@rdg.ac.uk">s.abeyasekera@rdg.ac.uk</a> |
| <a href="#">Carlos Barahona</a>     | Senior Statistician    | <a href="mailto:c.e.barahona@rdg.ac.uk">c.e.barahona@rdg.ac.uk</a>   |
| <a href="#">Ian Dale</a>            | Computing Consultant   | <a href="mailto:i.c.dale@rdg.ac.uk">i.c.dale@rdg.ac.uk</a>           |
| <a href="#">Cathy Garlick</a>       | Computing Consultant   | <a href="mailto:c.a.garlick@rdg.ac.uk">c.a.garlick@rdg.ac.uk</a>     |
| Lorna Turner                        | Executive Assistant    | <a href="mailto:l.e.turner@rdg.ac.uk">l.e.turner@rdg.ac.uk</a>       |
| Kellie Watkins                      | Centre Secretary       | <a href="mailto:k.watkins@rdg.ac.uk">k.watkins@rdg.ac.uk</a>         |



## APPENDIX 5

### MAPPING SPATIAL DATA

Rwakatungu Allan, Biometrics Unit , National Banana Research Program

#### Background

Mr. Jerome Kubiriba, a PhD student studying the epidemiology of BSV was interested in mapping the spatial spread of mealy bugs in his experimental plots to show that they were responsible for the spread of BSV.

**Figure A5.1 The data**

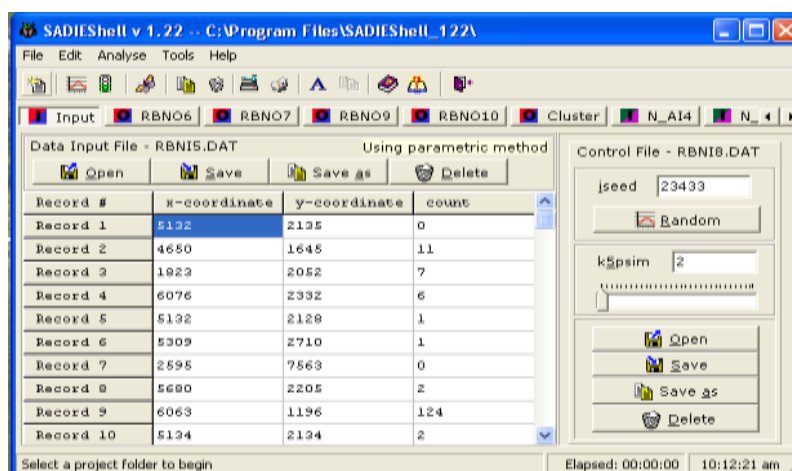
| Date       | X | Y  | COUNT |
|------------|---|----|-------|
| 24/10/2001 | 4 | 7  | 0     |
| 24/10/2001 | 4 | 8  | 0     |
| 24/10/2001 | 4 | 9  | 1     |
| 24/10/2001 | 4 | 10 | 0     |
| 24/10/2001 | 4 | 11 | 0     |
| 24/10/2001 | 4 | 12 | 0     |
| 24/10/2001 | 4 | 13 | 0     |
| 24/10/2001 | 4 | 14 | 2     |
| 24/10/2001 | 4 | 15 | 0     |

Figure A5.1 shows geo referenced data fitting the analysis. The variables are date of data collection, x row-coordinate of plant in the field and y column-coordinate of a plant in the field.

#### Analyzing the data

The major hurdle was obtaining cluster indexes that could be mapped. In comes the software SADIE. (For further information on this software see Annex A5.1). Sadie measures the degree of clustering in the data in the form of gaps and patches. The term cluster means a region of either relatively large counts close to one another in two-dimensional space (i.e. a patch), or of relatively small counts (i.e. a gap). Figure 2 shows spatial data after it has been imported into the SADIE software

**Figure A5.2 Spatial data after importing into the SADIE software**



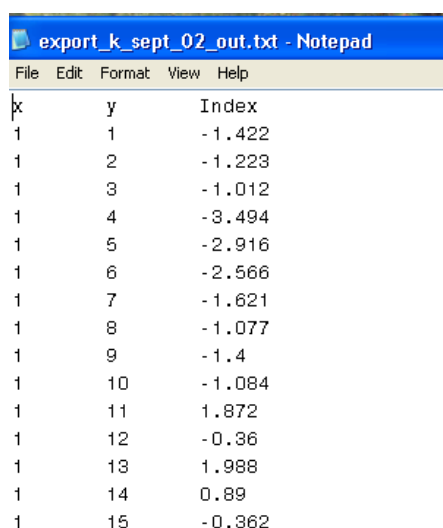


Other inputs into the analysis file include *iseed* and *k5psim*.

*iseed* (Integer seed), is a number between 1 and 30,000, for the random number generator. Specifying the same seed in successive runs of the program will generate identical randomizations; specifying a different value will result in different randomizations.

*K5psim* is a number between 1 and 153 that will determine the number of randomizations done. The program has got several outputs but the most important output is shown in Figure 3, i.e. the clustered indexes obtained.

**Figure A5.3 Clustered indices**

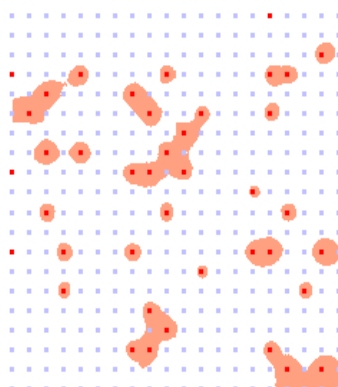


| x | y  | Index  |
|---|----|--------|
| 1 | 1  | -1.422 |
| 1 | 2  | -1.223 |
| 1 | 3  | -1.012 |
| 1 | 4  | -3.494 |
| 1 | 5  | -2.916 |
| 1 | 6  | -2.566 |
| 1 | 7  | -1.621 |
| 1 | 8  | -1.077 |
| 1 | 9  | -1.4   |
| 1 | 10 | -1.084 |
| 1 | 11 | 1.872  |
| 1 | 12 | -0.36  |
| 1 | 13 | 1.988  |
| 1 | 14 | 0.89   |
| 1 | 15 | -0.362 |

### Mapping the data

After the output has been obtained, it is exported to mapping software such as ESRIS ArchView or Surfer (for details of this software's see Annex A5.2). In the mapping software, contour maps are generated, colored and then re classified to show the 2 groups as gaps and patches to come up with a map as shown in figure 4.

**Figure A5.4 Result of mapping software**





## **Annex A5.1**

### **About SADIE**

SADIE is free software that is used measure and detects clustering, applied to data in the form of counts at specified spatial locations. The copyright in this software is vested in the employer, Rothamsted Experimental Station, Harpenden, Herts. AL5 2JQ UK, of its author Joe Perry. The software was developed using Microsoft FORTRAN PowerStation; it is supplied as a .EXE file and as source code, although you will not need to use the latter to run the program.

For more information visit <http://www.iacr.bbsrc.ac.uk/pie/sadie>

## **Annex A5.2**

### **About Surfer**

Surfer is mapping software developed by the Golden software Inc. and was recommended by the developer of SADIE as you could export data directly from SADIE into Surfer to plot the red blue contour maps .

For more information visit <http://www.goldensoftware.com>

### **About ESRIS ArchView**

This was developed by Environmental Systems Research Institute Inc. and is one of the most popular mapping software's. I got familiarized with this software while training at the Statistical Service Center of Reading University thanks to Ian Dale. However to use this software you require a spatial analyst add in before you can reclassify the data into red blue contour maps.

For more information visit <http://www.esri.com/>



# **Report on a Training Workshop on Research Data Management for staff of the Uganda National Banana Research Programme**

**2 and 4-6 June 2003**

## **1. Background and workshop aims**

As a component of the Project R8301/ZA0565 entitled “Archiving data ofrom integrated pest and disease management projects within the Uganda National Banana Research Programme (NBRP), funded by the DFID Crop Protection Programme, a 4-day training workshop was held in Uganda in the week 2-6 June 2003. The workshop was conducted by Savitri Abeyasekera and Ian Dale (Statistical Services Centre of the University of Reading) and Hussein Kisingo (Data Manager, IITA in Uganda). They were assisted by Yusuf Mulumba and Allan Rwakatungu, both from the Biometrics Unit at Kawanda Agricultural Research Institute, Uganda.

The main aim of the workshop was to train NBRP staff in effective management of their research data, paying special attention to data quality and validation. It was expected that the workshop would give staff a good appreciation of the need for managing their data in a systematic and organized way so as to facilitate subsequent data analysis and interpretation.

Prior to the workshop, participants were informed that workshop activities would involve looking critically at their own data sheets for data collection and they were therefore asked to bring along to the workshop a paper copy of their own data from a small study, together with background information relating to the data. They were also asked to bring along a protocol for a study with which they have had involvement, i.e. the study description and additional information necessary for understanding the corresponding data.

## **2. Workshop contents and style**

The workshop was largely based on materials in chapters 1-4 of course notes prepared by staff of the World Agroforestry Centre (previously the International Centre for Research in Agroforestry – ICRAF) in Kenya, modified slightly to suit the present audience. Five sessions were conducted as follows:

- Session 1 – Why worry about data management?
- Session 2 – Designing a spreadsheet for research data
- Session 3 – Effective use of spreadsheets for data entry and checking
- Session 4 – Why go beyond a spreadsheet?
- Session 5 – Exploratory Data Analysis.

An outline of the contents of each of these sessions is given in Annex 1.

Each session began with a short presentation, followed by group discussions and/or hands-on practical work. The first component of the latter generally included an example drawn from ICRAF's training materials, while the second component was based on participants' own data. In later sessions however, it was not always possible to proceed onto participants' own problems due to limited time availability.

The workshop was based largely on use of Excel for data entry and validation. A brief introduction to the database package ACCESS was given so that participants could appreciate the value of moving onto a database system for better integration of data across different studies (e.g. experimental studies, survey work, lab experiments, etc) within the same project.

Many handouts were given out during the workshop. These included copies of the presentations, practical handouts, extracts from the ICRAF training materials (particularly those relating to the practical exercises, and some additional supplementary documents, e.g. “Good tables in Excel”, “SSC-stat Tutorial”, “Disciplined use of spreadsheets for data entry” and “Data Management Guidelines for Experimental Projects”.



### **3. Workshop participants**

A list of participants who attended the workshop is given in Annex 2. The participants were a mixed group, varying from senior scientists within the programme, to technicians and data entry personnel. We felt this was a good mix since all staff needed familiarity with the processes of ensuring good data management within a programme where teamwork is essential.

The majority of attending participants were from NBRP. There were 4 participants from IITA.

We were also pleased to have the presence of the Head of the Banana Programme and the lead scientist associated with the CPP-funded IPM project R7567 during day 2 of the workshop to participate in the discussion on procedures and responsibilities for ensuring effective collection and management of banana data.

### **4. Workshop activities**

The first session proceeded well and participants learnt to appreciate how problems could arise in computerised data files. Working in groups, they also looked at data sheets of their own and were able to recognize limitations in their own work, particularly with respect to lack of attention to meta-data, i.e. related background information corresponding to the data being collected.

In the presentation for the second session, requirements of a good spreadsheet were discussed for both experimental and survey examples. A demonstration was given to show how plot identifiers could be set up, how drop-down lists are created to facilitate data entry, how validation checks are set up, how data auditing can be carried out, and the use of comments to highlight any curious features corresponding to individual cell values.

The practical exercise consisted of reading either the experimental protocol or the survey protocol provided to the participants and discussing the best design format for a spreadsheet to collect the required information. Participants were then asked to design an appropriate spreadsheet in Excel, setting up validation checks, etc.

Session 3 looked at the effective use of spreadsheets for data entry and checking. Group discussions helped in identifying procedures currently used within the banana programme for collecting the data, and persons responsible for data entry and checking. This session was also attended by the Head of the Banana Programme. An outline of some of the flip-chart notes used during the presentations made by group representatives appears in Annex 3. Practical work of this session included working through an example data set to carry out data checking procedures and to identify any curious or incorrect values residing in the data. During this session, participants also learned how to perform calculations in Excel for data checks, and to produce pivot tables.

Session 4 was used to highlight limitations of a spreadsheet for data management and for capturing specific types of data errors. A demonstration was also given of the facilities in ACCESS for performing more complex data management tasks more effectively than was possible within Excel's capabilities. The specific aim was for participants to appreciate that their current use of Excel for data entry was only a first step towards a more organized system for managing banana research data more effectively in the future.

Session 5 included a brief introduction to the Excel add-on SSCstat for data summary and data manipulations. There was unfortunately very limited time for participants to acquire reasonable skills in using this software add-on to Excel. Difficulties were also faced in finding that the add-on was not able to operate on previous versions of Windows. As such, larger groups of participants had to share the limited number of computers on which this facility was able to operate.



## **5. Feedback from participants**

Participants completed a workshop evaluation questionnaire. A summary of their evaluation is given in Annex 4. Their comments were on the whole very positive. Those participants who were largely involved in survey work felt that the examples were too focused towards the experimental scientists, but a discussion with one of them more recently revealed that the principles learnt had been found effective and beneficial in new survey work that was being undertaken.

One frequent comment was that the 4-day duration was too short and that more time was needed. This was very true. We were unable to complete all the exercises as planned. However, we feel that the training material covered was sufficient to give the participants a good feel for what was required to ensure a high level of data quality in all their research activities. A subsequent visit to the Banana Programme in late August also brought forth comments of appreciation by several of those who had participated in the training to indicate that they were now more aware of how to manage their data in a more systematic way. In fact, in association with the archiving activities of the CPP-projects, it was found that the data sets prepared were now of a higher standard, demonstrating some of the skills acquired during workshop activities.

Workshop activities also demonstrated a clear indication that participants were highly motivated and keen to receive training of this nature, and would welcome more training courses in the future. The data entry personnel in particular were very appreciative that they were given the opportunity to participate in the training and felt that they could now be more effective in capturing data errors at the entry stage. One of them also requested that this type of training is conducted on a regular basis.

### **Acknowledgements:**

A special thank-you goes to Hussein Kisingo, Yusuf Mulumba and Allan Rwakatungu for their participation, interest and assistance during this workshop. We would also like to thank the World Agroforestry Centre for supplying many copies of the training course materials for this workshop.

**Savitri Abeyasekera and Ian Dale**  
**Statistical Services Centre**  
**The University of Reading**  
**6<sup>th</sup> September 2003**



# **ANNEX 1**

## **Research Data Management Workshop for the National Banana Research Programme in Uganda**

**2 and 4-6 June 2003**

### **Workshop Contents**

#### ***Session 1 - Why worry about data management?***

- What is meant by data management?
- Main steps in the data management process
- Recognising common problems in recording sheets and computerised data

#### ***Session 2 - Designing a spreadsheet for research data***

- Recognising the data structure
- Setting up a spreadsheet for data collection and entry
- Checking the spreadsheet (use of pivot tables, pilot testing, etc.)
- Saving and naming files
- Practical work on spreadsheet design

#### ***Session 3 - Effective use of spreadsheets for data entry and checking***

- Who is responsible for the tasks involved?
- Guidelines for data entry
- Guidelines for data checking (including use of pivot tables)
- Keeping an audit trail
- Organising the data for analysis
- Practical work on spreadsheet data entry and checking

#### ***Session 4 - Why go beyond the spreadsheet?***

- Limitations of a spreadsheet for data management and for capturing specific types of data errors
- Practical exercises to illustrate above limitations for six different tasks
- Demonstrating the benefits of a database package (MS Access) for performing the above tasks efficiently and accurately

#### ***Session 5 - Exploratory Data Analysis***

- Introduction to SSCstat
- Using summary statistics
- Practical exercises



## Annex 2

### PARTICIPANT LIST

| No | NAME                           | Designation        | Project         | Program                          | Email  |
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| 15 | Mr David Kaganda               | Research Assistant | IITA            | IITA                             | <a href="mailto:Dtinka@kari.goug">Dtinka@kari.goug</a>                 |
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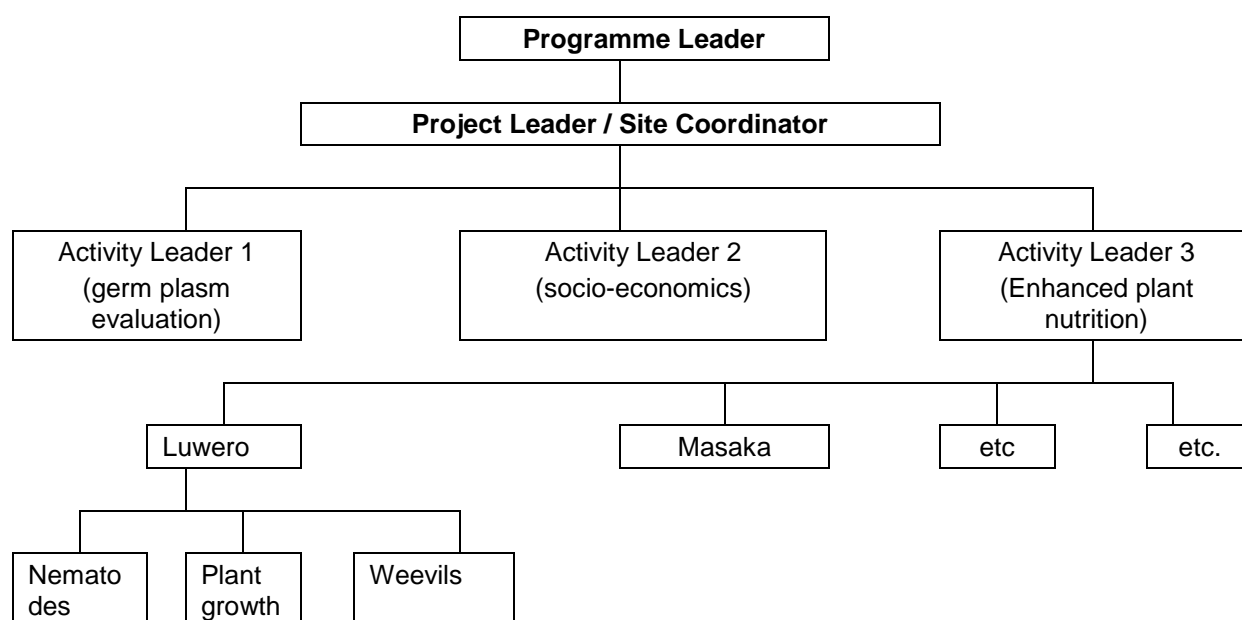


## ANNEX 3

### Research Data Management Workshop

#### Results of group presentations on data management process

##### (a) Banana Research overall organisational set-up



Note was made that checking of data is done by activity leader, helped by site coordinator

##### (b) Organisation of activities in technology dissemination (reported by Josephine)

- Researcher prepares data sheets.
- Data collection activities should be agreed with extension officers
- Researcher does the data cleaning and passes to data manager.
- Statistician will be involved from the start and should approve the data sheets.
- Data manager will also check the data and maintain data back-ups.
- Need to make all involved aware of the objectives.

##### (c) Organisation in breeding work (reported by Priver)

Key players are: scientists, technicians, biometricians, field assistants, farmers, research managers, i.e. the project leader and administrator.

First is the problem identification by farmers and scientists.



Subsequent stages are:

- Preparation of project proposal (setting objectives, defining activities, time frame, budget) by project leader/scientist, and biometrician.
- Site identification – done by project leader
- Field assistant – layout, marking field positions – done by scientists, technicians, labourers, farmers.
- Continuous activities of field management – done by field assistant.
- Data collection – scientist does the data collection sheet, and technician does the actual collection.
- Data processing – for lab work, data is entered immediately after data collection, while for field work, data entry is done at the time when the analysis is required.
- Reporting – is done by project leader.
- Master copy of data is kept by project leader (Research Assistant does the back-ups).
- Raw data sheets are kept by the Technicians.

**(d) Organisational activities in lab / on-station / on-farm research projects (reported by Caroline)**

- Project development and funding – done by senior scientists
- Implementation of project involves a number of study activities. Each includes:
- Writing protocols – done by lead scientist
- Planning the experimental design and methodology – by lead scientist, student, biometrician
- Setting up the experiment – field plan must be available – if on-farm it is done by field assistant, farmers, labourers. If on-station, lead scientist is responsible.
- Data collection – lead scientist to coordinate. This involves: data entry, validation, analysis, keeping raw data and computer version (with activity leader).
- Reporting
- Back-ups and archiving.

Notes 1: Activity leader can be leader of project or research assistant or student.

Notes 2: In weevils project (R7972) same sheets used for both data collection and data entry.



## Annex 4

### Workshop Evaluation Questionnaire Results

#### Course Impact

1. How *useful* did you find the course?

Very useful      Not useful

2. How *demanding* did you find the course?

Very easy      Very difficult

#### Did we get it *right*?

Too little

Too much

1. Amount of material covered

2. Practical content

3. Statistical knowledge assumed

4. Computing knowledge assumed

#### General

1. How did you rate the overall *standard* of teaching?

Very good    Very poor

2. How did you rate the *quality* of the course notes?

Very good    Very poor

3. Would you *recommend* the course to other people?

Yes  Perhaps  No

If no, please give your reason(s).



## Individual Sessions

Please indicate your level of *understanding*:

|   | Thorough understanding |    |    | Little understanding |   |
|---|------------------------|----|----|----------------------|---|
| 1. Why worry about data management? (SA)          | 11                     | 11 | 1  |                      |   |
| 2. Designing a spreadsheet for research data (SA) | 7                      | 14 | 2  |                      |   |
| 3. Spreadsheets for data entry and checking (SA)  | 9                      | 9  | 5  |                      |   |
| 4. Why go beyond the spreadsheet? (ID)            | 5                      | 7  | 7  | 2                    | 2 |
| 5. Exploratory data analysis (SA)                 | 3                      | 4  | 11 | 5                    |   |

Further comments on any of the above or any other aspects of the course (e.g. teaching style, practical work, quality of food, facilities, ...)

1. More time for the course would have been better for more understanding.  
The little time available was efficiently utilized.
2. Teaching materials were well prepared and organised.  
Teaching style was very good in that every session, practical exercises could be conducted.  
I appreciate the quality of food served.
3. The course should be run a bit longer, could be broken down into different sessions, one building on another over period of time.  
Good because practical work predominated but more time needed.  
Meals were good (quite).
4. Some participants did not come with their own data so could not practice with it. In future ample time should be given for people to work with their own data sets.  
Very little was taught on Microsoft Access and how to work with data base other than Excel spreadsheets.
5. I enjoyed the course very much because it was touching actual problems we face everyday in research. It was not too complicated to understand except where the "stranger" ACCESS was being introduced in a limited time  
Thank you! Please we want some more!
6. I felt the course was extremely useful to me and many up coming young researchers but I felt we needed more time than 4 days. I think we need more time for practice and individual consultations, I am hopeful that the window will be open through mail for further disturbances (I mean consultation).
7. This course was/is necessary for staff members to know about good data quality and management.



8. Next time you should put in more survey examples and put on board survey resource person.
9. We needed much more time for practical sessions to understand the difficult parts of the course.
10. More time should have been allocated for the course  
Data management using MS Access should have been covered in more detail.  
The course focussed more on experimental data in future survey data should also be covered in detail.
11. The time allotted for other final package SSC seemed inadequate to explore the numerous advantages of the package.
12. All the above were good enough to impact the necessary skills to the participants. A job well done. Thanks.
13. No comments given.
14. The Teaching style and attitude of the instructors was very good mainly because they even found time to interact with us and find out our problems during the proceedings.
15. Exploratory data analysis would require practice with a data set we were more conversant with.  
Appreciation of the course Instructors, they really made it easy because of the free atmosphere.  
(Interpersonal relationship with us)  
Food quality excellent!!
16. Teaching was excellent, practical work was well conducted. Food quality was good.  
Funds ought to be availed for periodical training of similar category to keep staff abreast with good data management skills.  
Course should have taken longer.
17. There was a need to do more practical work. We covered too much material in a short time.
18. Teaching style was excellent as it provides practical examples for us to practice. I would recommend that such a course is brought back in case new staff come in after a specific period of time e.g. 5 years.
19. Some computers are of old model making some practical work difficult or not possible at all otherwise it was a nice workshop.
20. No comments given.
21. Need for more time (2 weeks) to grasp the content properly (both for theory and practicals).
22. Food quality poor. Teaching style was very good, not a lot of forcing but with lots of practical work.
23. The course was very educative, I have come to understand why I need to have good quality data right from the beginning of the project to the end. However it was such a short course and I would like to have more of such courses in future. Otherwise I liked the course organisation it was of high quality. Thank you, come again.



**National Agricultural Research Organisation, Uganda  
Kawanda Agricultural Research Institute, Kampala**



# **Guidelines and Procedures for Effective Data Management**

**(with emphasis on banana research)**

*Prepared by*

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May 2004

**DFID** Department for  
International  
Development



**The University of Reading  
Statistical Services Centre**





## **Foreword**

Guidelines and procedures provided here for effective management of research data have been developed by staff of the National Banana Research Programme (NBRP), National Agricultural Research Organisation, Uganda, in collaboration with the Statistical Services Centre of the University of Reading, U.K. It is intended to assist researchers working within NBRP to develop and adopt international best practices that will ensure data of high quality are collected and managed in a way that will facilitate data analysis procedures and subsequent achievement of research objectives. This document together with a parallel document outlining NBRP's policy for research management is expected to produce a streamlined approach for researchers to follow throughout the research process so that high quality research outputs can be achieved on the basis of reliable data that can be trusted by other researchers and policy makers.

The development of these guidelines has been funded by the Crop Protection Programme (CPP) of DFID UK, a key donor to several research projects within NBRP. CPP recognised the need for the development of an effective database management system for research activities within NBRP and agreed in early 2003 to fund initial activities that would support NBRP in achieving this goal. The funding covered the archiving of all data, meta-data and study protocols of the CPP-funded cluster of banana projects, the setting up of guidelines and procedures necessary for maintaining a good database management system, and developing an appropriate data management strategy for all NBRP research activities. This document forms the second of these three outputs.

Continuation of data management activities within NBRP is now proceeding with Rockefeller funding being available for the development of a database management system for NBRP, based on a prototype called "Logbook" developed at the World Agroforestry Centre in Nairobi. It is expected that the development of a "Banana Logbook" will help banana researchers to conveniently manage data of high quality along with associated metadata. There will also be the benefit of retrieving data in different formats and in particular, allowing analyses that will integrate data across different study components, thus providing a more interdisciplinary approach to research findings. I urge all research staff of NBRP and others in NARO to make the best use of this manual.

Dr. G.W. Otim-Nape  
Ag. Director General  
National Agricultural Research Organisation, Uganda

## **Note**

The authors and contributors to this manual encourage other researchers to adapt and adopt these guidelines to suit their own research programmes. However, full acknowledgement should be given to the National Banana Research Programme, KARI, Uganda and its collaborating partner, the Statistical Services Centre at the University of Reading in the U.K., for the initial production of these guidelines.



## Acknowledgements

Funding from the Crop Protection Programme of the UK Government's Department for International Development (DFID) for the development this manual is gratefully acknowledged but the views expressed here are not necessarily those of DFID.

We would like to extend our thanks to Philip Ragama (IITA) for helping with the final editing of this document, to Fred Bagamba and Magara Evarist for assistance with preparing the activity protocols, to Cecilia Mugume for secretarial support and to Ian Wilson (University of Reading, U.K.) for initially promoting good data management within NBRP.

We would also like to thank others within the National Banana Research Programme who assisted in many ways through contributions during meetings and informal discussions, namely Dezi Ngambeki, Caroline Nankinga Kukiriza, Magara Evarist, Tumuhaise Venansio, Muhangi Justus, Josephine Namaganda, Nora Odoi, Fred Bagamba, Robert Natumanya, Mapiira Samuel, Enid Katungi, Kikulwe Enoch, Wycliffe Tumusiime, Linda Atiku, George Martin Acire, Africano Kangire, Henry Mwaka, Ssali Reuben Tendo, Drucilla Nakalanzi and Batte Micheal. Our thanks extend to similar contributions received from staff of the International Institute of Tropical Agriculture, namely Philip Ragama, Hussein Kisingo, David Kaganda, Robert Kawuki, Godfrey Kagezi, William Tinzaara, Mugabi Matovu and Mukasa David, and from Peter Muraya (World Agroforestry Centre, Nairobi).

## Citation

Murekezi, C., Abeyasekera, S., Mulumba, Y., Rwakatungu, A., Kubiriba, J. and Tushemereirwe, W.K. (2004). *Guidelines and Procedures for Effective Data Management (with emphasis on banana research)*. National Banana Research Programme, Kawanda Agricultural Research Institute, Kampala, Uganda, 35 pp.

A pdf version of PART I of this manual can be downloaded from <http://www.banana.go.ug>. PART II of this manual is available at <http://www.reading.ac.uk/ssc/develop/dfid/booklets.html>

## Acronyms

|      |   |
|------|---|
| NARO | National Agricultural Research Organisation |
| KARI | Kawanda Agricultural Research Institute     |
| NBRP | National Banana Research Programme          |
| DMG  | Data Management Guidelines                  |
| DRS  | Data Recording Sheet                        |
| FA   | Field Assistant                             |



# PART I – Data Management Guidelines

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## PART II - Resource Materials on Data Management

SSC (1998). *Data Management Guidelines for Experimental Projects*. The University of Reading, Statistical Services Centre Guidelines Series for DFID. Available at <http://www.reading.ac.uk/ssc/>

SSC (2000). *Disciplined Use of Spreadsheets for Data Entry*. The University of Reading, Statistical Services Centre Guidelines Series for DFID. Available at <http://www.reading.ac.uk/ssc/>



# **Guidelines and Procedures for Effective Data Management**

## **PART I**

### **Data Management Guidelines**



# 1. Introduction

1.1 The guidelines in this manual for research data management have been developed and accepted by researchers within the National Banana Research Programme (NBRP), based at the Kawanda Agricultural Research Institute in Uganda. It is intended primarily for banana researchers for projects involving primary data collection activities, and hence many of the illustrative examples are drawn from work within NBRP. However it is also expected to be a useful resource for researchers working within other NARO programmes. It is not intended to be prescriptive but to raise awareness of issues that need to be considered and addressed in order to achieve an effective data management system for researchers within NBRP. These guidelines assist in the implementation of the policy adopted by NBRP to improve its research quality and should be read in conjunction with the document describing NBRP's Policy for Research Management (UNBRP, 2004).

1.2 There are many other valuable sources which provide guidance on procedures for effective management of research data. The most useful of these is the ICPSR Guide (2002) aimed specifically at Social Science Data, but the recommendations within that guide are equally applicable within other subject disciplines. Further resources can be found in Part II of this manual.

1.3 Good data management requires linking the numerous research activities within a project to one another so as to produce an integrated approach to achieving the project's overall goal. These guidelines therefore begin with an overview of the research process and then provides more detailed guidelines on procedures that will lead to establishing an effective data management system within NBRP.

## 2. The Research Process

2.1 Figure 1 provides a framework for the overall research process. Collecting the right data for the right purpose at the right time requires the researcher to clearly keep in mind the overall project purpose and the research objectives serving that purpose. This facilitates identification of specific research questions to address each research objective. This in turn helps in determining the research activities and data needs. Box 1 provides an example illustrating items 1., 2., and 3c., of the framework in Figure 1.

### Box 1. First Steps in the Research Process – An Example

This example is drawn from an integrated pest management project, whose overall **project purpose** was to promote strategies to reduce the impact of pests on banana production with the aim of improving food security, income and livelihoods for the benefit of rural poor households in Uganda.

One of its **research aims (outputs)** was to evaluate cultivars with different yield/growth characteristics for disease and nematode resistance under farmer field conditions.

Some **research questions** addressing this research output were:

(a) Exotic banana cultivars recently introduced to Uganda have shown promise during on-station trials with respect to agronomic performance and pest/disease resistance. *How well would these (in particular FHIA 25, PITAB8, PITA 14, PITA 17 and SABA), perform under farmer management?*

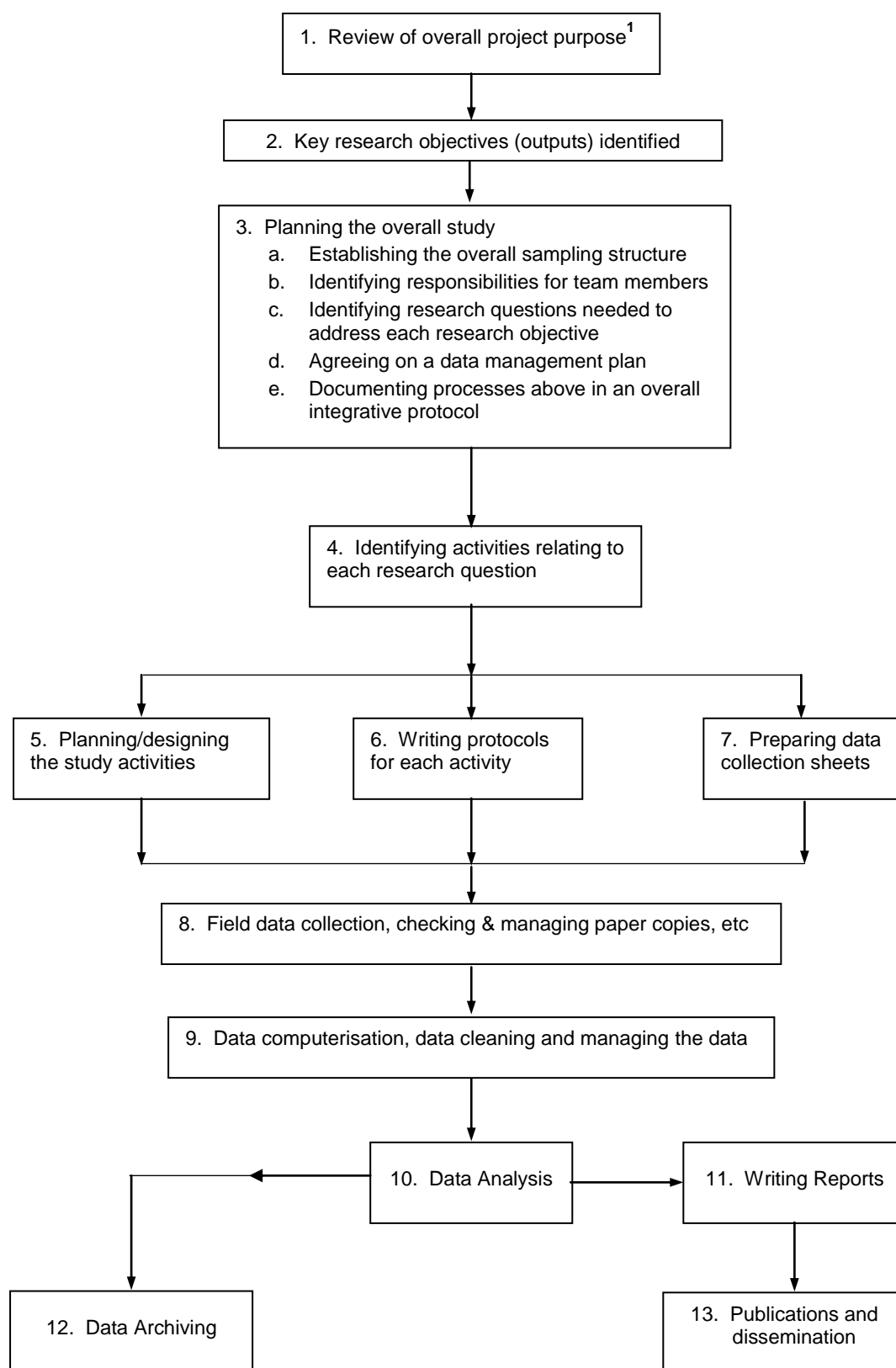
(b) If the above questions revealed that one or two of the exotic cultivars perform well under farmer conditions, *are these results consistent across all the farmers included in the trial? If not, can socio-economic characteristics, or other farm-level characteristics be used to explain why?*

(c) Is good agronomic performance of one or more cultivars supported by farmers' preferences for adoption of these cultivars?

(d) Cavendish cultivars are known to be high yielding and resistant to fusarium wilt pathogen, and have the potential to replace Gros Michel (Bogoya), and also serve as an export crop for Ugandan farmers. Although they are susceptible to leaf spot diseases in lowland (e.g. central Uganda), at higher elevation (e.g. western Uganda) Cavendish cultivars may be appropriate. *How well would Cavendish cultivars, along with FHIA 17, bred specifically with black leaf streak resistance in mind, perform in Ntungamo and Mbarara districts with respect to agronomic performance and disease resistance under farmer management?*



**FIGURE 1. A Framework for Effective Data Management<sup>1</sup>**



<sup>1</sup> This assumes that the process of identifying a researchable problem, resulting in a funded project with a clear purpose, has been followed. (See UNBRP, 2004).



2.2 Identifying specific research questions will typically happen during the Planning Meeting for the overall study (item 3 in the framework, expanded in section 3 below). At this time activities will be identified to address each of the research questions (item 4 in the framework). These activities may require different subject area specialists. If this happens, a series of sub-projects will arise, requiring several scientists and/or research assistants or technicians, to supervise activities within the sub-project.

2.3 For example, addressing research question (a) in Box 1 may require an agronomist, a pathologist and an entomologist. Each will envisage different data collection activities but close collaboration amongst them is needed with respect to several issues, e.g.

- i. Co-ordinating the timing of sub-activities aimed at addressing the research question.
- ii. Agreeing on identification (ID) numbers to be used in the different data collection forms, i.e., in case of on-farm/surveys research farmer numbers, and for on-station experiment block/plot numbers. There must be a consistent system across the different activities.
- iii. Agreeing on the format of protocols for the research questions being addressed, and person responsible for writing it.
- iv. Identifying who will coordinate the above activities and be the point of contact for the Project Leader.

2.4 Once activities for each research question are identified, they will require action on each of the steps in the framework (Figure 1) from steps 4 through to step 9. Thereafter some analyses will first be undertaken for the activity and then there will be an integrative analysis to answer the research questions. Data archiving and reporting will follow. Sections 4 to 9 of this manual provide guidelines for items 5, 6, 8, 9, 12 of Figure 1.

## 3. Planning the Study

### 3.1 Establishing the sampling structure

3.1.1 A well-documented process for sampling field-plots, households, farms, geographical areas or other units, is needed in the form of a Sampling Protocol (see SSC, 2004). This should include the method of sampling, i.e. how are units selected, with appropriate justification, how many units will be sampled, how often sampling should be done, etc.

3.1.2 If the sampling methodology involves several stages of sampling (e.g. district, sub-county, parish, village, farm) then requirements specified in 3.1.1 have to be addressed **at each stage** with appropriate justification. In doing so, it would be helpful to study available information concerning the full set of units occurring at each stage. For example, in a specific district, how many sub-counties are available for possible inclusion in the sample, how many parishes in each of the chosen ones, how many villages in each parish, and so on.

3.1.3. Research objectives have to be kept in mind during the process of sampling and the sampling coverage must be in accordance with available resources.

3.1.4 As an example, the research outlined in Box 1 will require answers to the following questions.

- i. What population (of farmers and/or areas) is/are being considered for applicability of research findings?
- ii. Where (on which specific farms) will the trial be conducted?
- iii. How will the farmers be selected?
- iv. How many will be selected and why? Are these numbers feasible within available resources?
- v. What criteria would be used in farmer selection and why?
- vi. When will the farmer selection be done and by whom?

3.1.5 For further guidelines on sampling issues consult SSC (2000a) and Wilson (2000).



### **3.2 Identifying responsibilities for team members**

3.2.1 For data management to be effective, it is desirable to have a clear allocation of responsibilities for different components of the work by researchers, data managers, research assistants, technicians, field assistants and data entry personnel. (See also 3.4.1 below).

3.2.2 It is likely that for any study implemented by the NBRP with several collaborators, a Data Manager will be needed, e.g. a research assistant designated to be the Data Manager.

### **3.3 Identifying research questions, activities and data**

3.3.1 The process of identifying the research questions has already been dealt with in discussing the research process in section 2. It relates to data management indirectly in that the research questions lead to research activities, and activities often involve collecting data. If they are sufficiently and clearly defined, research questions and activities should serve to identify exactly what data has to be collected and why. The latter would be detailed in activity protocols (see Box 3 and Appendices 2-6).

### **3.4 Preparing a Data Management Plan**

3.4.1 Having a clear data management plan is a crucial requirement if project data is to be managed properly to ensure good quality data analysis outputs. The plan should include procedures for, and person(s) responsible for

- i. monitoring progress on data collection activities
- ii. managing the data recording sheets
- iii. checking data from the field as to their validity according to scientific expectations
- iv. preparing the data recording sheets (DRS)
- v. setting up data-entry screens and checking the data after entry
- vi. carrying out exploratory data analysis (EDA) to find (and correct) any further errors in the data
- vii. archiving the data and meta<sup>2</sup>-data.

Guidelines for some of the above are given in sections below.

### **3.5 Preparing an integrative project-level protocol**

3.5.1 The project as a whole will need an overall “integrative” or “project-level” protocol. This will encompass the needs of the project as a whole and will help in the delivery of its outputs and achievement of its overall goal. It will be concerned with ensuring that linkages (i) to (iv), mentioned above, are effectively made. This is of most value to the research project leader, and would also provide the donor with a quick assessment of the status of the project’s progress at any one point in time.

3.5.2 An integrative protocol will include material similar to what researchers include in their project proposal. It will explain **why** the research is needed, and **what** outputs will serve to address these needs. It will then list a series of activities to demonstrate **what** will be done to achieve the suggested outputs. Usually this is done in the project proposal only in very broad terms and little attempt is made at linking the different activities to show **how** they collectively contribute to the overall research goal. Box 2 provides an example of how study activities link within a single project.

3.5.3 The integrative protocol also needs to (a) demonstrate the uptake pathways for the research, i.e. **how** the results will be disseminated and used; (b) **when** and in what form the data will be archived; (c) **who** will be responsible for the archive; (d) **where** the archive will be kept, and (e) **who** will have access to this archive.

3.5.4 Preparing the integrative protocol will be the responsibility of the Project Leader. Appendix 1 provides an example of an integrative protocol for a project with several major components.

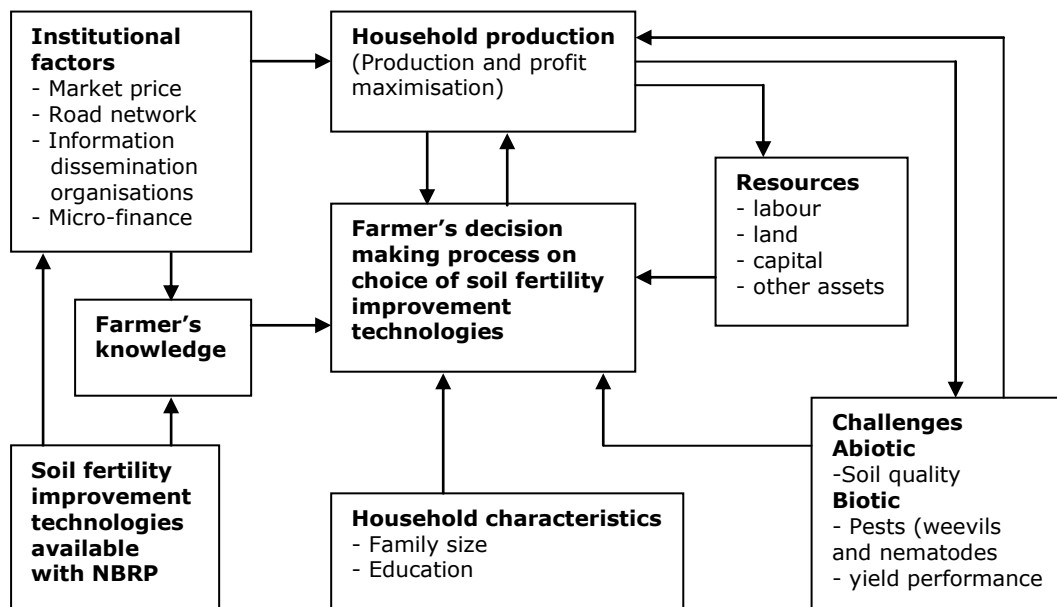
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<sup>2</sup> Meta data refers to all background information related to the numerical data (e.g. full description of all measurements, maps, questionnaires, etc), together with other associated information such as photographs, reports, talks and other presentation material.



## Box 2. An illustration of how research components in a project link to each other

A conceptual framework of how research components of a project on soil fertility management in bananas, being conducted at the Masaka NBRP benchmark site, link to each other.



It is hypothesized that farmer's decision making on the choice of soil fertility improvement technologies is based on costs and benefits. This is subject to factors like soil quality, production and profit maximization, resources available to the farmer, household characteristics, an exogenous source of technologies (from research) and institutional factors that impact on farmer's knowledge. For example, a farmer could decide to use his indigenous knowledge (e.g. fallow, crop residues, ash and animal manure and urine) to maximize production. On the other hand, farmers' with limited land could maximize production by adopting soil fertility improvement technologies. Their decision of choice of soil improvement technologies will be subject to resources available to them, their household characteristics, yield performance of soil technologies in face of pests, existence of appropriate soil improvement technologies from research initiatives and enabling institutional factors, i.e., good market prices, good road network, existence of information dissemination organizations and possibility credit facilities.

With this conceptual framework in mind, an on-farm study on the economics of soil fertility management was designed in Kisekka sub-county, Masaka district, involving forty farmers. The main output of the study was establishing the costs and benefits of soil fertility improvement technologies (manure, mulch, fertilizer and a combination of mulch and fertilizer) with a view to recommending the most beneficial technology in terms of maximising farmers' banana production and profits. To achieve this output, the study was divided into the following research components:

- a socio-economic component - to study the farmers' household characteristics, the institutional factors, farmers' knowledge, resources available to the farmers leading to an cost benefit analysis of the technologies
- Agronomy component - to study the yield performance of the soil technologies
- Entomology component - to study the interaction of weevils on the yield performance of soil fertility improvement technologies, since predominantly used cultural measures to manage pests are not particularly successful.
- Nematology components - it was established that fields infested with the root burrowing nematode *Rhodopholus similis* do not respond to soil fertility improvement technologies. Trial fields were, therefore, monitored for nematodes.



## 4. Planning/designing the study activities

### 4.1 Planning meetings

4.1.1 During planning meetings concerning an activity, it is necessary to consider in turn answers to the what, when, where, why, who and how questions with respect to that activity. For example, an on-farm experimental activity such as that in research question (a) of Box 1, needs to answer:

- i. Who will be responsible for planning and implementation procedures (name Activity Leader)?
- ii. What specific experimental treatments will be explored in the trial? Will it be just the 5 cultivars of interest, or would a local (control) cultivar also be included?
- iii. Will any other factors (e.g. mulching treatments) be included? If so, why?
- iv. Where in each farm will the experimental plots be set up, and why?
- v. What will be the experimental design layout (including number of plots, number of blocks, plot size, randomisation used, type of design with reasons for choice, materials to be used, etc)?
- vi. How many replications will be obtained over the whole trial?
- vii. How will the trial be set up and when?
- viii. Who will collect the data and how (and how often) will the trial be monitored?

4.1.2 For each activity, it is also important to ask the following questions with respect to the actual data being collected and to justify why each item of data should be considered. Some questions in this respect are given below. Box 3 provides an illustration.

- i. What measurements will be made during the experimental trial, survey or participatory study, and why?
- ii. How will each specific measurement help in answering the research questions?
- iii. How will each measurement be defined and described?
- iv. What analysis plan is envisaged from this data to enable all research questions to be answered?
- v. When will the different activities take place?
- vi. Who will be responsible for each of them?

4.1.3 On-farm trials aimed at testing new technologies present a special challenge at the planning stage. Too often, natural scientists tend to design on-farm trials similarly to how they would design on-station trials. This is rarely appropriate. The number of plots required, even for one replicate of the “treatments” being explored, will be too many for the farmer to manage effectively. Incomplete replicates should be considered, together with an increase in the number of farmers included in the trial. This has added benefit that conclusions from the research are more widely generalisable. The main point to note is that experimental design concepts, as well as survey design concepts come into play when designing on-farm trials to assess new technologies. For further guidance see SSC (1998c).

### 4.2 Activity Protocols

4.2.1 Discussions during activity planning meetings should be followed immediately afterwards by the preparation of an activity protocol by the activity leader, so that decisions and action points agreed during the meeting are clearly documented. Such a protocol will generally describe **how** each activity will be done, **what** procedures would be undertaken in carrying out the activity, **when** and **where**, and by **whom** will it be done, and **how** and **why** the completion of that activity will achieve the desired output. This will essentially capture the information given in the example in 4.1.1 above.

4.2.2 Typically, a single project will have several “Activity Protocols” relating to the different research activities within the project. These must however demonstrate the way in which they link to each other and to the overall integrative project protocol. In general they will be internal to the team. They will be invaluable in many ways, e.g. they will (a) allow each member of the project team to very easily understand the details of each activity and thereby facilitate linkage between the different research components; (b) enable all of the meta-data to be accumulated together in a form that feeds easily into a project data archive with minimum cost; and (c) facilitate better overall management of each research activity with a clear understanding of its progress and level of achievement.



### **Box 3. Illustration showing how data collection variables are specified and justified**

This illustration is drawn from an on-station experiment to elucidate the interactions between BSV and crop management on banana crop productivity using modern physiological techniques to quantify resource use by the crops. The experiment was conducted at Kawanda Agricultural Research Institute and ran from October 2001 to July 2003. The variables mentioned below were measured during a 1st ratoon banana crop.

#### **Climatic data**

Air temperature, wind speed, relative humidity and incoming solar radiation were sampled at 3 m above ground and recorded hourly with a CR10 datalogger (Campbell Scientific, Pullman, WA) for the period 2001 and 2002. The expression of BSV symptoms are influenced by climatic conditions among other factors. The climatic conditions were monitored in the experiment to explain any variations in symptom expression attributed to climate

#### **Soil**

- i. Soil water was measured in plots with a neutron probe (Institute of Hydrology, Oxfordshire, U.K.). Two access tubes were installed 3 m apart mid way in each plot. Soil moisture was measured at every 0.2 m from the soil surface to a depth of 1.6 m. Measurements were done weekly, from March 2002 to July 2002.
- ii. Top and sub-soils were sampled for baseline measurements. Top soil sample alone were collected from each plot 14 months after the initiation of the experiment (in January 2002) which coincided with the third month of the 1st ratoon crop. Soils were analysed for the analysis of N, P, K, Ca and Mg.
- iii. Soils bulk density. Measurements were taken before and 14 months after experiment establishment.
- iv. Daily soil temperatures were measured by placing Tinytag data loggers (Gemini data loggers, U.K. Ltd), between 10 – 20 cm in the soil in the different crop management treatments.

Crop management treatments comprised mulching, fertilizing and no weeds on one hand and no mulch, no fertilizer and infrequent weed control, on the other. These treatments impact on crop productivity through the regulation of soil conditions. Therefore, it was imperative to measure the indicators of soil conditions important for crop production, namely, soil water, nutrients and temperature so as to explain the treatments effects on crop productivity.

#### **Crop growth, development and yield**

- i. Plant height and girth (circumference of the pseudostem) at 1 m from the base of the pseudostem, of individual plants in each plot were measured at flower emergence. These were indicators of growth.
- ii. Development was measured by recording the phenological events for each plant, namely, date of sucker emergence, leaf emergence, flower emergence, and maturation, from which the total leaf production, vegetative and reproductive/fruit development durations were calculated.
- iii. At maturity the fruit (bunch) was harvested, weighed and the number of hands recorded.

The impact of BSV is best explained by quantifying its effects on yield, therefore, necessitating measuring fruit (bunch) weight and number of hands per bunch. Since yield culminates from the processes of growth and development, it was important to determine the effect of BSV on banana growth and development. The effects of diseases on the growth of plants are related to certain development stages. It is imperative that the stages of banana development at which BSV has greatest influence are ascertained. This would give an indication of the timing of practices aimed at managing the disease. The interaction between crop management and BSV on banana productivity would be described through the measurement of plant growth, development and yield.



**Disease assessment**

BSV leaf symptoms on each plant were assessed monthly and a disease severity index will be calculated based on a 0-3 scoring scale (Dahal et al, 1998). This was to quantify disease severity of the plants with BSV and establish those plants without BSV.

**Physiology data**

- i. Destructive sampling was done in December 2001, March 2002, May 2002 and July 2000 for the 1st ratoon crop cycle to determine dry matter increases. Two plants (one with symptoms and one without) will be randomly selected in each sub-plot and harvested into leaves, pseudostem and corm. Thereafter, the plant parts were oven dried at 70°C for 48 hours, giving dry weight.
- ii. Light interception was measured using a Sunflecks Ceptometer for plants that were to be destructively sampled. Incident light above the banana canopy was measured using sensors in an open area next to the banana experimental field. Light transmitted at the base of each banana plant canopy was an average of several readings measured by sensors at 12 points around the plant.

Destructing sampling and light interception measurements were used to quantify resource use (light capture) by bananas with and without BSV. This would further clarify the impact of BSV on banana productivity and the interaction between BSV and crop management.

4.2.3 The activity protocol must link clearly and effectively to other stages in the project, and often to other parts of an overall research programme. For example, the protocol for an activity such as a survey or experiment has to link to (i) higher levels in the research framework, e.g. the inception form of the project memorandum; (ii) predecessor activities and their results which bear directly on the activity now considered; (iii) parallel activities, e.g. a socio-economic survey with which the on-farm study is to be linked in analysis; (iv) later-phase work including analysis, reporting, uptake, promotion and impact assessment.

**4.3 Examples of activity protocols**

4.3.1 Appendix 2 of UNBRP (2004) gives the general format of an activity protocol. In Appendices 2, 3, 4, 5 and 6 of this guide, we provide several examples of activity protocols for a range of activities which may form components of a research project. However some components of the protocol have been deliberately left incomplete for brevity. They are intended to demonstrate aspects of what might be expected in activity protocols of different types, and we therefore provide protocols for (i) a farmer participatory study pest/disease perceptions; (ii) an on-farm study on evaluation of exotic banana cultivars; (iii) an on-station study of the effect of climate and crop management on incidence and severity of banana streak virus; (iv) a laboratory study of the infectivity of different *B. bassiana* formulations to the banana weevil; and (v) a survey of determinants of resource allocation in low input agricultural systems. Further examples may be found in SSC (2001), Case Study 7, drawn from other DFID-funded research projects, and in SSC (2004).

**4.4 Other protocols relevant as part of research activity planning**

4.3.1 Many projects will also have a sampling protocol which describes the target population and the procedures used for sampling individual units from the population elements. In addition, a data management plan will form a major part of the Data Management Protocol.



## 5. Guidelines for preparing data recording sheets (DRS)

### 5.1 Preparing questionnaires for survey work

5.1.1 Preparing a good questionnaire is not a trivial task and sufficient time has to be allocated for this purpose. Unless the questionnaire is well-designed, there will be little of value from the survey, so setting up its structure and formulating the questions needs careful thought with due consideration to the survey objectives and subsequent analysis approach.

5.1.2 The actual structure and contents of the questionnaire will depend on the specific survey in mind, but some general guidelines are quoted in Box 4 from SSC(1998a).

### 5.2 Preparing checklists and data recording sheets for participatory studies

5.2.1 Where focus group discussions (FGDs) are held with (say) farmers, to explore some issue, take to the field a check-list of topics to be covered. However, before proceeding to the field, the field procedure to be undertaken should be agreed and documented very carefully in a Field Operations Manual. A data recording sheet (DRS) should also be prepared in advance to capture the main points emerging from the FGD in a structured format. The latter is essential if the information gathered is to be analysed meaningfully to give conclusions that are generalisable to the target population. The protocol in Appendix 2 provides an illustration of components that may form a Field Operations Manual and a DRS.

#### **Box 4. An extract from SSC (1998a) for guidelines in developing questionnaires**

- There is increasing evidence that a thoughtfully-prepared introduction can be very important as it establishes a rapport. For example it dispels any suspicion that the questioner works for the tax-gatherers, it introduces the themes and purpose of the survey. The introduction also develops the respondents' mind-set, for example by getting respondents to go over past events and recall situations that will inform the interview. Practice during training, and effective supervision, should ensure interviewers reliably cover the right topics.
- Transparency of intent should be established in the introduction and by following clear lines of questioning e.g. sections on household demographics, land tenure, crops, livestock. Within sections, it may be useful to follow a regular sequence of question types e.g. facts, practices, knowledge, attitudes and beliefs.
- All questions to be included must be consistent with the objectives of the survey. It is often when the questionnaire is being planned that realisation dawns that the objectives have not been specified sufficiently precisely.
- Constructing an effective questionnaire is a time consuming process. Researchers inexperienced in questionnaire design should recognise that it is easy to construct a questionnaire, difficult to construct one that is effective. To avoid rambling or obscure questions, put some issues and words in (i) a preamble, (ii) lists of permitted answers, or (iii) reiteration, confirmation, and extension of the first response.
- If questions demand recall, should checklists be given to help memory-jogging? Partial lists may bias the response pattern.
- How many alternatives should be given for attitude questions? Often there are five, ranging from "strongly agree" to "strongly disagree", unless one wishes to deny the respondent the lazy choice of a mid-point, which sometimes has no meaning. Careful thought is needed to "profile" attitudes meaningfully. Often informants ought to participate directly in deciding the importance of profile elements.
- Open questions, which allow freer expression, require disciplined data collection and may be difficult to summarise.
- Translators inexperienced in survey design may not appreciate the precision required in question wording, and with completion instructions and units of measurement. Look out too for formally correct translations that are dialectally or culturally inappropriate.
- There is information from past studies to help with constructive approaches to many problems of questionnaire design. Ask those with relevant experience.



### **5.3 Preparing a recording sheet for on-station and lab-based experimental studies**

5.3.1 Most scientists would be familiar with the preparation of a DRS for on-station or lab-based experimental studies. However, what is often missing is a clear explanation of what each variable is, and the units used to measure them. The *who*, *when* and *how* questions are also generally unclear. We would recommend that this additional meta-data is carefully documented in the activity protocol and subsequently included in the corresponding data file.

5.3.2 Usually it will be possible to prepare the sheet in a format (say in MS-Excel) that could be used without change for both data recording and data entry. Treatment codes, sample numbers, and other experimental details could be entered in advance so that only the actual measurements have to be recorded during the study. SSC(2000b) provides further guidance.

### **5.4 Preparing a recording sheet for on-farm trials**

5.4.1 Preparing a DRS for on-farm trials is a greater challenge than the equivalent for an on-station trial. It must be piloted in the field situation and modified accordingly. Dates of recording different pieces of information are important, as are plot numbers, plant numbers, treatment codes, etc. Identification codes that allow the data to be linked to other activities within the project are very necessary.

5.4.2 There must be space on the sheet for comments. This is very important since unexpected events often happen and the data collector must be made aware of the need to note any unexpected occurrences or interesting features. These can relate either to the actual plant being measured, the plot, the trial, the farm or the household. Space alongside each row of the data matrix, for comments relating to plant and plot numbers or household (in the case of a survey), and space at the bottom of the sheet (for trial level or farm or household related comments) is highly desirable.

5.4.3 Units for measurements must be clearly specified, and if they vary from farmer to farmer (e.g. units of fertiliser applied by the farmer), then there should be a separate column in your data sheet to note down the measurement units used.

5.4.4 If farmer names are used, have a single list with names consistently spelt across all parallel activities involving the same farmers. This list should be circulated among team members during initial stages of project planning, and the same form and spelling of the name used on all forms and data entries. This needs careful checking.

5.4.5 Further guidelines concerning the preparation of the DRS can be found in SSC (1998b), sections 4 and 5, available in Part II of this manual.

### **5.5 Data at hierarchical levels**

5.5.1 With surveys, participatory studies and on-farm experimental studies, data are often collected at different hierarchical levels, e.g. some data at plant level, some at plot level, some at farm level. Unique identification codes must be decided in advance of data collection to ensure that data across the different hierarchies can be linked together.

5.5.2 If MS-Excel is used for data entry, it may be appropriate to use different sheets within the same workbook for data from different hierarchical levels, linked by appropriate identification codes.

### **5.6 Suitability of the data collection sheet for use in data entry**

5.6.1 Check that the data entry screen used on a pc for data entry is reasonably compatible with the data collection sheet. Often it may be possible for the two to be exactly identical. This facilitates the process of data entry immediately after data collection.

5.6.2 Ensure validation checks are set up on your data entry screen. See guidelines under section 8 below for further details.



## **5.7 Pilot testing the DRS at field level**

5.7.1 All data collection instruments as listed above, and any others relevant to the project, must be pilot tested in the field prior to commencement of actual data collection. This will allow any unforeseen difficulties to be recognised and addressed. It will also help determine the ease with which the DRS can be used under field conditions and the time taken for the work. If the first pilot run results in major modifications to the DRS, a second pilot is highly desirable.

5.7.2 After the pilot run is complete, the data gathered will be entered to check on the suitability of the data entry screens. It would be desirable for the Activity Leader to do this jointly with the data entry person. If the DRS needs major modifications, data from the pilot run should be discarded. Where the data are retained, there should be an additional column to separate data from the pilot run with data subsequently collected.

5.7.3 We strongly recommend a further step to ensure that the DRS captures the data in a way that is compatible with the planned format for data entry. After a small component of the data has been collected, this should be computerised as soon as possible and efforts made to produce some simple summaries or graphs. This will help to highlight possible deficiencies that may still remain in the data collection process, the DRS and/or the computer screen. Any remaining problems should be noted at this stage and resolved following guidelines in 5.7.4 below.

5.7.4 Every effort should be made to avoid making additions or changes to the DRS after actions above have been completed. However, where there are very strong reasons to do so after data collection activities begin, the following procedures are strongly recommended.

- i. If new objectives are included within the study, data for this should be captured as an additional module without changing the original DRS.
- ii. If it is deemed essential to change any specific component(s) of the DRS, data from the "new" component(s) should be computerised using one or more additional variables.

In both the above cases, the actions taken should be clearly indicated in the activity protocol and the computerised data files, and implications for data analysis considered.



## 6. Guidelines for data collection and checks at field level

### 6.1 Training and supervision of field staff

6.1.1 Training those who will actually do the data collection (including on some occasions, the farmers), is extremely important if good data is to result from the research activity. It is also highly desirable to involve the field staff while preparing the data collection sheets. This will serve to raise their awareness of the objectives of the research, and to confirm they are comfortable with the researchers' expectations and the suitability to farmers of the language used and any demands made on interviewers' and respondents' accuracy at mental arithmetic. Box 5 shows an example.

#### **Box 5. An illustration of training procedure for field staff**

This example is drawn from a project on "The economics of soil fertility management in banana production" conducted Masaka bench mark site (See Box 2).

Procedure undertaken was as follows:

- Two field assistants were recruited full-time on the project. They were to collect data in farmers' fields relating to the research components of the project that required monitoring at bi-weekly intervals. These were: Socio-economic variables; agronomic variables like plant height, pseudostem girth, flowering date, harvest date, number of hands per bunch and bunch weight; and pest variables like weevil damage. Variables like soil nutrients, nematode abundance and damage, and farmer knowledge (perception on soil fertility) were collected by the research team.
- The field assistants spent one week with the Activity Leaders and other activity members (Research Assistant, Technician) for training on how to collect data on the variables, to prepare data collection sheets and test these on-station. A schedule of when the field assistants should visit the farmer was also prepared on-station.
- Another week was spent on farmers' fields to start off the process of data collection. Adjustments were made to the data collection sheets and farmer visit schedule depending on the field conditions to ease the field assistants' work.
- Activity leaders and research team visited the farmers' fields once a month during the rain months only (8 months a year) to carry out fertiliser application. Data collected by field assistants were re-checked at this stage. It was found that the schedules for collecting socio-economic data, weevils data and agronomic data could be better coordinated and the field process simplified by further small modifications to the data recording sheets. This was done ensuring that the previous data could still be transferred to the modified format without loss of information.

6.1.2 Adequate supervision of the field data collectors is needed and they must be made aware that the accuracy of their field data collection processes are being monitored. The supervisor (ideally the scientist who leads the activity), needs to check each data sheet that is returned from the field for consistency and reliability, in particular, to check that the data are consistent with scientific expectations. Any queries should be raised with the data collector as soon as possible.

6.1.3 Supervisor checking should be according to a checklist of specific things that the supervisor does, notes, calculates or ticks-off. The checklist should be prepared in advance of the data collection and is necessary because a mere "general read" of the DRS can miss something important.



6.1.4 Due to the very high variability in banana harvesting dates, farmers may be asked to record information on harvest date and bunch weight. It is then necessary to adhere to clearly defined procedures for collecting the information. First, the FA, during his fortnightly visit to the farmer, should record an eye estimate of the possible harvesting date and bunch weight of any plant that is likely to be harvested in the following 2 weeks. In his next visit, he will check these against the farmer records to ensure that the two records are reasonably compatible. Otherwise the FA needs to ascertain (with the farmer) the reasons for any major difference. Both the estimated and actual records should appear on the DRS. This process requires that the same FA will visit the farmer each time.

6.1.5 Where field data collection involves repeat visits to the same farm using the same DRS, the FA will bring the DRS to the Activity Leader once a month, say on the first Monday of each month. It is recommended that the FA then follows one of the two procedures below.

- i. The FA will collect a duplicate set of blank DRS to take to the field to continue with data collection. Before doing so, he/she will record in the second set (say with a tick mark), those cases for which data have already been collected so that the gaps in the DRS (for further additional data) are clear. By the time the FA returns a month later, computerisation of the first set of data will be complete, so that a printed version could be taken to the field with gaps (for which data has been collected in the interim period) marked on the printed forms. The process will repeat each time the FA visits KARI.
- ii. The FA will photocopy the returning set of DRS, pass the photocopy to the person doing the data entry, and take his/her original DRS to the field to continue with data collection. He/she will return a month later with additional data, photocopy again this updated set of DRS, leave the photocopy for data entry and return to the field with the original set. The process will repeat each time the FA visits KARI.

## **6.2 Validation/Consistency checks at field level**

6.2.1 It is important that the data collector is always conscious of the actual measurements being recorded in terms of their numerical values or grouping levels (e.g. high/medium/low), and whether they are consistent with previously recorded values as well as with other measurements being made at the same time. For example, the flowering date must be at a time after the sucker emergence date by roughly 9 months under good management and about 12 months under poor management. In turn a farmer's record of harvesting date must necessarily be a date later than the flowering time by about 3 months for local and East African Highland bananas and about 5 months for exotic cultivars. If the farmer also records banana bunch weights and price for which they are sold, there ought to be some correspondence between the weight and price records for a given cultivar. Any inconsistencies should be clarified with the farmer at the time of data collection. The FA needs to be trained in above aspects of data collection and the DRS needs to prompt FA as to what he/she needs to do at each point.

6.2.2 Sometimes the data records are reliable but unusual or unexpected. Possible reasons for this should be discussed with the farmer and noted on the recording forms. Even an entry like "this record is unusual but it was checked, and discussions with the farmer did not provide a reason for this unexpected value" will be very useful at the data analysis stage. Such comments should also be transferred subsequently to the computerised data file, e.g. as a cell comment in an MS-Excel spreadsheet.



## **7. Guidelines for data computerisation and checking**

### **7.1 Data computerisation**

7.1.1 Data should be entered as soon as possible after data collection is complete to enable data queries to be checked with data collectors. Main features to be considered when data are to be computerised, and which should form a part of the Data Management Protocol, are the following.

- i. Understanding the data structure.
- ii. Identifying the types of information being collected.
- iii. Specifying the measurement units.
- iv. Having a strategy for data entry (who, when, how, software for entry, doing double data entry or manual checks, etc).
- v. Having a strategy for storing of raw (unedited) data files (where, who, when, etc) and filing of paper copies of the DRS.
- vi. Keeping an audit trail, i.e. a complete record of changes to the data and decisions made about the data and the analysis, rather like a notebook for keeping a log of activities.
- vii. Procedures for backing-up files and updating the master copy of the data.

These features are discussed in greater detail in SSC (1998b, 2000b). Both these documents are available in Part II of this manual.

7.1.2 There is a consistent format for naming computer files for work within NBRP according to the following guidelines.

- i. NBRP operates at specific benchmark sites. Hence all data-related computer files will begin with L, Ma, Mb, Nt or R for data collected at sites Luwero, Masaka, Mbarara, Ntungamo and Rakai respectively. Where more than one site is involved, there will be reference to all three sites in the form Nt&Ma&R....., for data from Ntungamo, Masaka and Rakai.
- ii. The remainder of the data file name should give a very brief description of the contents of the file, including a reference to the year of the activity or any other qualifiers, ensuring that the filename is unique across all project computer files.
- iii. It is recommended that further descriptors of the data file be included in the file description properties<sup>3</sup>.

### **7.2 Data Checking**

7.2.1 Capturing of data entry errors is minimised if validation checks are set up on the software system being used for data entry. Guidelines on setting up data entry screens and validation checks can be found in SSC (2000b) in Part II of this manual.

### **7.3 Organising the data for analysis**

7.3.1 We recommend that guidelines given in section 8 of SSC (1998b) (see Part II of this manual) are followed during the process of organising the data for analysis.

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<sup>3</sup> Use the menu sequence *File, Properties*, to access the dialogue where further details can be retained.



## 8. Guidelines for data checking during analysis

### 8.1 Exploring the data with summary statistics

8.1.1 Carry out simple descriptive summaries for all variables selected for analysis. This will include frequency tables for categorical variables, and summary statistics (number of cases, mean, maximum, minimum, standard deviation) for the quantitative variables. The maximum and minimum values in particular are useful indicators of possible data errors.

8.1.2 Some variables like *number of years farmer has experience of growing bananas*, *age of household head*, etc, may be summarised initially as frequency tables so that appropriate re-grouping into a smaller number of categories may be identified (if it is appropriate to do so). Here, it is important to check that any re-coding of the variables has happened as expected, e.g. by checking the frequency distribution of the original variable with that of the new, re-coded variable.

8.1.3 If the main variable for analysis is quantitative (e.g. bunch weights), one may consider producing tables giving counts and mean values of this variable across the categorical determinants that may potentially affect bunch weights, e.g. cultivars grown, education level of household head. Also consider plotting the key outcome (say bunch weights) against other quantitative determinants (say amount of fertiliser inputs, % soil nutrients (N say)).

8.1.4 If the key response of interest is categorical (e.g. whether level of bacterial wilt in the field is high, medium or low), consider producing tables giving counts and mean values of the quantitative determinants (say number of clusters) across values of your categorical outcome. Also consider tables of counts and percentages of the key categorical outcome against other categorical determinants.

8.1.5 Look carefully at the results from 8.1.1 to 8.1.4 to ensure they make sense. Check also that codes set for missing values (e.g. 999) have been explained in the meta-data component, and that any data transfers between software packages (e.g. ACCESS to SPSS) has correctly transferred the missing values and not, for example, set them to be zeros. It is important to be aware of capabilities within your software for dealing with missing values. Any oddities should be checked against the original questionnaires or experimental recording sheets. Further data cleaning may happen at this stage. **Ensure the data are corrected in the Master database** and in any other analysis that uses the variables now corrected.

### 8.2 Exploring the data through use of graphical procedures

8.2.1 Graphs and charts are valuable tools in data exploration prior to starting more formal data analysis procedures. Consider producing for example,

- i. *Box plots*, to compare groups of data and highlight outliers;
- ii. *Scatterplots* between quantitative measurements are especially valuable if separate colours or symbols are used for different treatments or socio-economic groups;
- iii. *Bar charts, multiple bar charts, graphs in time order*, can be useful for identifying trends and in particular, any departures from expected trends.

### 8.3 Checks after data modelling procedures

8.3.1 Residual analyses are valuable for conducting further checks after statistical modelling procedures such as analysis of variance or regression. They can lead to the identification of data errors and odd values that may have been present but not previously identified because of confounding factors.



## 9. Guidelines for data archiving

9.1 Within NBRP, the archiving of raw data, meta-data, reports and protocols will be done continuously during the project's duration. As reports are prepared, and as data sets are created and cleaned, these will be named according to agreed conventions (see 7.1.2) and passed to the Biometrics Unit for inclusion in its central data archive. Copies should however be retained by the Activity Leader.

9.2 At a minimum, the data should be organised according to a sensible filing structure. An example is provided in Appendix 7 for DFID –funded banana research projects.

9.3 Refer also to sections 4.5 and 5 of UNBRP (2004). Further details can be found in ICPSR (2002), SSC (2001)-Case Study 6, and in Lawson-McDowall et al (2001).

## 10. References

ICPSR (2002). Guide to Social Science Data Preparation and Archiving. Inter-university Consortium for Political and Social Research. Available at <http://www.icpsr.umich.edu/org/publications/index.html>.

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SSC (1998a). *Guidelines for Planning Effective Surveys*. The University of Reading, Statistical Services Centre Guidelines Series for DFID. Available at <http://www.reading.ac.uk/ssc/>

SSC (1998b). *Data Management Guidelines for Experimental Projects*. The University of Reading, Statistical Services Centre Guidelines Series for DFID. Available at <http://www.reading.ac.uk/ssc/> (and also in Part II of this Data Management Guidelines Manual).

SSC (2000a). *Some Basic Ideas of Sampling*. The University of Reading, Statistical Services Centre Guidelines Series for DFID. Available at <http://www.reading.ac.uk/ssc/>

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UNBRP (2004). Uganda National Banana Research Programme Policy for Research Management with emphasis on Research Data Management and Statistical Analysis. Kawanda Agricultural Research Institute, Kampala, Uganda, 14 pp. Available at <http://www.banana.go.ug>

Wilson, I.M. (2000). *Sampling and Qualitative Research*. Theme Paper for DFID project on "Integrating qualitative and quantitative approaches in socio-economic survey work". Available at <http://www.reading.ac.uk/ssc/>



## APPENDIX 1

### Example of an integrative Project Protocol

**Project Title:** Farmer participatory banana research at Kisekka bench mark site, Masaka district

**Project Manager:** Dr. W.K. Tushemereirwe

**Research Partners:** ITA, ICIPE, CABI, NRI, INIBAP, University of Reading, Makerere University

**Project Funding:** The Rockefeller Foundation (RF), the International Development Research Centre of Canada (IDRC), DFID and Uganda Government

**Start and end dates:** 1999 – 2003

#### Project Purpose:

The purpose was to validate and disseminate technologies/ knowledge for improving banana production and utilisation, under farmer conditions.

#### Project Justification:

A research agenda involving a rapid rural appraisal, constraint assessment surveys and constraint intervention research, was developed at the inception of the NBRP. This agenda has been the main focus of NBRP activities and has resulted in studies to characterise banana constraints and develop interventions. Some of the technologies/knowledge developed (in collaboration with IITA, NRI, CABI & INIBAP) include: Highland banana hybrids with resistance to pests and diseases, exotic bananas from foreign banana breeding programmes; entomopathogenic biopesticides, enhanced cultural control practices for management of pests and diseases; improved crop and soil management practices; and new methods of utilising bananas. A menu of these technologies was selected during a PRA by farmers in Kisekka benchmark site for validation under their conditions. Subsequently, a farmer participatory approach, involving a multidisciplinary team of researchers in bananas, research collaborators, service providers and farmers, was adopted in the validation of the technologies. It was envisaged that the approach would enable the fine tuning of the technologies and increase the uptake of farmer validated banana management/utilisation technologies.

#### Specific Project Objectives:

- (i) To capture all the activities members of selected households are engaged in and their relative shares of time over a 12-month cycle.
- (ii) To validate the effect of a combination of mulch and inorganic fertilizer for improved banana production.
- (iii) To assess the cost effectiveness of a common herbicide (Roundup) compared to other weed control practices in banana production.
- (iv) To train farmers on alternative methods of post harvest handling of banana produce and evaluate utilisation options of dehydrated bananas.
- (v) To determine the most appropriate technique for the rapid multiplication of high yielding East African bananas and empowering farmers to manage banana multiplication gardens
- (vi) To evaluate new banana cultivars under farmer conditions.
- (vii) To evaluate pheromone enhanced traps for the control of the banana weevil.

#### List of intended Outputs:

- i. Labour allocations to banana activities determined.
- ii. An appropriate combination of farmers' mulch and inorganic fertilizer for increase banana yields established.
- iii. The cost effectiveness of herbicides versus hand hoe weeding established and benefits of herbicide use demonstrated.
- iv. Alternative post harvest handling techniques of bananas demonstrated and utilization of dehydrated bananas evaluated
- v. An appropriate technique of rapidly multiplying bananas, under farmers' conditions, determined and banana planting material made available for dissemination to other farmers through multiplication gardens.
- vi. Agronomic performance and acceptability of new banana cultivars determined.
- vii. The efficacy of pheromone enhanced traps in managing the banana weevil established



**Research disciplines corresponding to project objectives:**

- i. Socio-economic factors influencing banana production
- ii. Soil fertility management in banana production
- iii. Economics of weed control technologies
- iv. Post harvest handling and utilization technologies of bananas
- v. Multiplication of planting materials
- vi. Evaluation of new cultivars and farmer acceptability for dissemination
- vii. Banana integrated pest management technologies

**Research questions with justification:**

- i. Results of a baseline survey in Kisekka reported that labour was a big constraint to banana production and that farmers were engaged in activities other than bananas. Is it that there was labour scarcity in general or labour for banana production and IPM in particular was not cost effective?
- ii. A combination of organic and inorganic fertilizer is proposed as a sustainable option since it reduced dependence on organics (e.g. mulch coffee husks) which are bulky, have a high labour requirement and are increasingly becoming scarce. How would a combination of mulch (commonly used organic material in Kisekka) and inorganic fertilizer improve the agronomic and yield performance of bananas, under farmer conditions?
- iii. The baseline survey established that 37% of the total man-hours required for the maintenance of 1 hectare of bananas was spent weeding the crop, largely by hand hoe. Herbicides were used in coffee gardens mainly, but rarely in bananas. Is it that herbicides use is not cost effective in banana plantations?
- iv. Banana utilization is largely in the fresh form which contributes to post harvest losses especially during the peak production that coincides with the dry season. During this period the farm gate price is low and a large amount of banana production is lost. Is it that farmers lacked skills in drying bananas to extend shelf-life for utilization during periods of scarcity? Which utilization options of dehydrated bananas were acceptable?
- v. Farmers reported that they lacked planting material of improved banana cultivars like Mpologoma. What are the most appropriate means of rapidly multiplying planting material for farmers?
- vi. New cultivars have been evaluated in some parts of the country and have been found to be resistant/tolerant to common pests and diseases and have some potential uses. However, do these cultivars meet the farmers' criteria for adoption?
- vii. Trapping with pseudostems is a recommended practice in the control of the banana weevil, but its adoption is limited because of its labour requirement. Pheromone baited traps have been developed as an efficient and less labour intensive alternative. How effective are these pheromone enhanced traps in farmers' banana gardens?

**List of research activities (in chronological order):**

The farmers at Kisekka cleared the following 7 studies to be validated at the benchmark site.

- i. Labour utilisation and factors affecting allocation of time and labour to banana production and IPM (Dr. J. Ssenyonga, F. Bagamba. and E. Katungi).
- ii. Use of a combination of organic and inorganic fertilisers for management of soil fertility in bananas (C. Murekezi and Dr. H. Ssali).
- iii. Economics of herbicides as a control measure for weeds in bananas (F. Bagamba).
- iv. Use of new cultivars for control of banana fusarium wilt (Dr. Kangire and K. Nowankunda).
- v. Dehydration and utilisation options of dried bananas (M. Pekke and K. Nowankunda).
- vi. Rapid field multiplication of banana suckers for the high demand cultivars (Dr. J. Namaganda).
- vii. Use of pheromone – enhanced traps for management of the banana weevil (W. Tinzaara, G.H. Kagezi, and C. Gold).

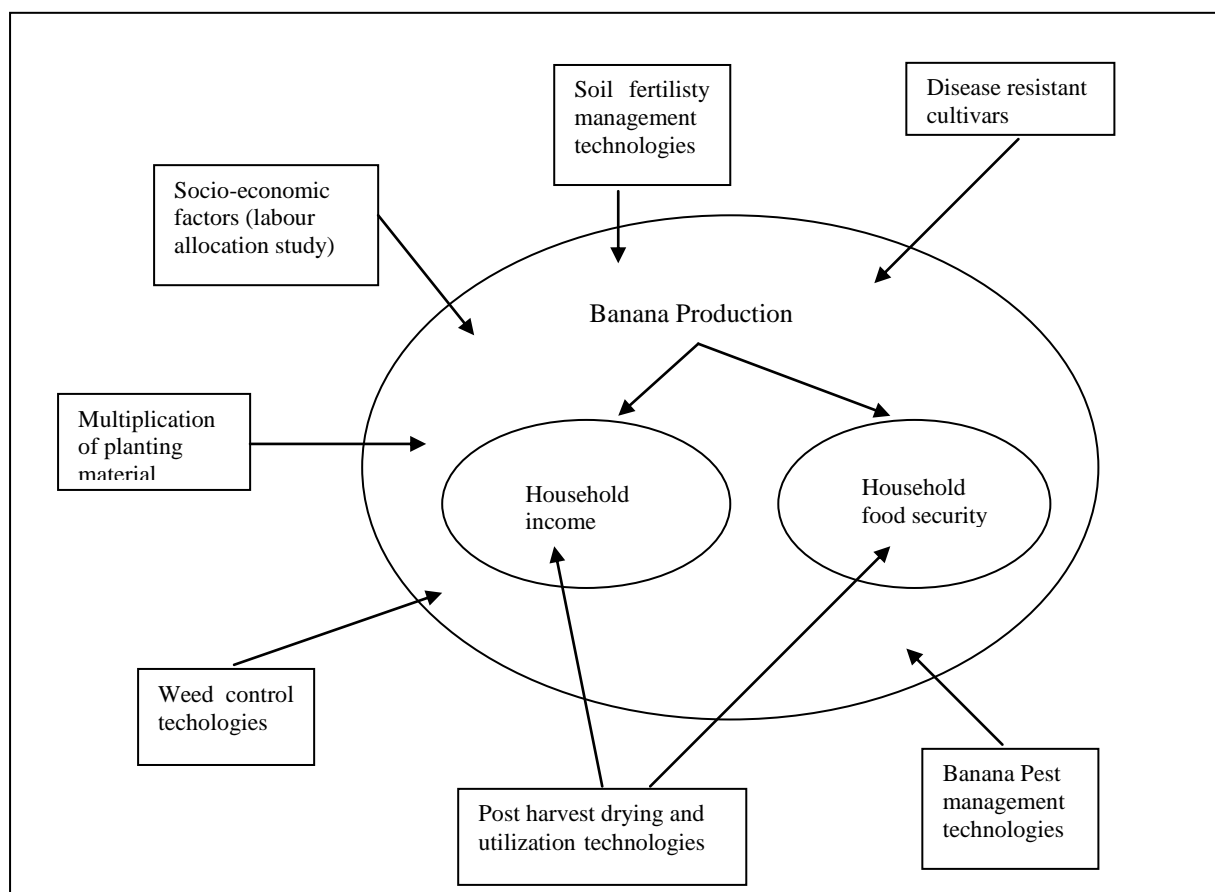
**Conceptual Framework:**

The NBRP contributes to the national goal of improving household food security and income through the generation and supply of technologies to 'up-take pathways' aimed at improving the production and post handling and utilization of bananas grown in Uganda. Understanding the socio-economic factors influencing banana production, appropriate weed control, soil fertility and pest technologies, availability of disease resistant cultivars and planting material for the farmers are hypothesized to increase farmers' banana production. This in turns improves their household



food and income situation. Appropriate post harvest drying and utilization technologies will influence the household food situation and in so doing the household income. As shown by the conceptual framework below, the studies lead to the increase in banana production and ultimately the welfare of the household. To increase the participation of farmers in the validation process, each study was hosted by a separate sample of farmers.

### Error!



### Brief sampling protocol:

A series of meetings were held within the NBRP involving the Project Leader, researchers involved in the activities and a biometrician. Each activity was reviewed and a farmer selection framework agreed on. The process of farmer selection was done in collaboration with the site local leaders, extension workers and farmers. Lists of banana farmers were obtained at parish level and each Activity Leader developed a preliminary list of farmers to host his/her study.

The activity leaders proceeded to visit the listed farmers accompanied by extension staff and local leaders to explain to the farmers the purpose of the studies. Farmers were requested to volunteer to host the studies after it was ascertained that their banana gardens met the research study criteria. Thereafter, farmer meetings were held at each of the 7 parishes of Kisekka sub-county, involving all the activity leaders, local leaders, extension workers and farmers. At these meetings, the lists of farmers meeting the research study criteria were presented and selections of farmers to host the studies were made by their peers basing on their own criteria. The farmer's selection criteria mainly involved interpersonal and communication attributes that were viewed as important in the dissemination of knowledge/technologies from the farmers hosting the studies to the wider community.

After the farmer selection process, a meeting was convened at Kisekka sub-county headquarters by the Project Leader in which the selected farmers, their peers, local leaders, extension workers, service providers and researchers participated. An implementation plan was agreed stipulating the roles and responsibilities of the researchers, participating farmers and extension staff. Subsequently, each activity leader proceeded to implement the research studies.



**Procedure for implementing each study activity:** The table below gives an outline of the procedures.

| <b>Activity</b>   | <b>Who? (research team)</b>                                | <b>How activity is done</b>  | <b>When done</b>    |
|---|--|--|---------------------|
| Labour utilisation and factors affecting allocation       | Dr. J. Ssenyonga, F. Bagamba. and E. Katungi               | Stratified sample of 21 households randomly selected. Households visited bi-weekly and percentage share of time and labour of each activity recorded   | Jan 2000 - Jan 2001 |
| Use of a combination of organic and inorganic fertilisers | C. Murekezi and Dr. H. Ssali                               | 15 farms. Three mulch categories (self, light and adequate external mulch) with 4 fertilizer rates imposed in a RCBD with 5 replicates. Agronomic characteristics compared   | 1999 - 2003         |
| Economics of herbicides as a control measure              | F. Bagamba   | 7 farms. Two ½ acre plots on each farm. One plot sprayed with herbicide and other hand hoe weeded. Labour and inputs assessed. Costs and benefits analysed.  | 1999 - 2001         |
| Use of new cultivars for control of fusarium wilt         | Dr. Kangire K. Nowankunda, M. Nakyanzi and Dr. C. Nankinga | 37 farms. Each farm established 5 plants of each of cultivars FHIA 17, FHIA 23 and KM5. Compared for agronomic performance and consumer acceptability  | 1999 - 2003         |
| Dehydration and utilisation options of dried bananas      | M. Pekke and K. Nowankunda                                 | 12 farmers participated in drying of matooke and ndizi on raised rakes. Banana flour based products and confectionaries produced and tested for consumer acceptability   | 1999 - 2003         |
| Rapid field multiplication of banana suckers              | Dr. J. Namaganda, Dr. C. Nankinga and W. Tushemereirwe     | 7 farms with 80 mats each. Five treatments per farm: (i) manure; (ii) manure + decapitation; (iii) Inorganic fertilizer; (iv) inorganic fertilizer + decapitation; and (v) control. Treatments compared for sucker emergence and farmer acceptability. | 1999 - 2003         |
| Use of pheromone – enhanced traps                         | W. Tinzaara, C. Gold and G.H. Kagezi                       | 42 farms of ¼ acre. 0, 4 and 8 traps/ha were the treatments with each farm as a replicate. Weevil populations and damage were estimated at 0, 6, 12, 18 and 21 months and treatments compared  | 1999 – 2001         |

#### **Data management protocol**

Data collection, data entry and checking, organizing the data achieving keeping back files etc. were carried out by the activity leaders (A formal data management protocol was not written, but this is highly desirable and will be done for future projects, following guidelines in this manual).

**List of documents relating to the Project:** This will be updated over the duration of the project and will include planning meeting minutes, workshop reports, progress reports, short technical documents, etc. These will help in checking items for inclusion in the project archive.

1. Minutes of meeting of banana programme scientists to review and make a preliminary plan for the Banana Research Programme: 18-19<sup>th</sup> May 1999, Banana Resource Centre, KARI.
2. Minutes of meeting with Programme Leader held 6<sup>th</sup> July 1999 to discuss the farmer selection exercise in Kisekka sub-county, Masaka.
3. Proceedings of review workshop of farmer participatory banana research activities held at Kisekka sub- county headquarters, Masaka district held on July 2000. 92p
4. Kawanda Agricultural Research Institute Annual Report 1999/2000. 127p
5. Kawanda Agricultural Research Institute Annual Report 2000/2001. 60p
6. Farmer participatory development and promotion of banana management options that suppress weevils, black sigatoka, nematodes and bacterial with. 2003FS039. Project Progress Report. March 2004.

**Plans for dissemination:** <This is likely to be specified in the project proposal but either a reference to the proposal or a brief outline of what is intended is beneficial here>

**List of publications, conference papers, and other technical articles:** <This list would generally get updated as the project progresses>



## Appendix 2

### An activity protocol for a farmer participatory study

**Activity Title:** Farmers' knowledge and perceptions of banana diseases and pests

**Project Title:** Promotion of improved IPM practices for banana diseases and pests in Uganda

**Project Leader:** Dr. Caroline Nankinga Kukiriza

**Activity Leader:** C. Murekezi

**Other members contributing to the activity:** <to be determined>

**Project Funding:** DFID Crop Protection Programme

**Research Partners:** NBRP-NARO, CABI, University of Reading

**Start and end dates:** October 2003 to March 2005

#### *Background:*

A primary requirement of the project (which this activity is serving) is to better inform farmers (and associated stakeholders) of prevailing major pest and disease constraints and of the potential benefits of "technologies" that are applicable to alleviating them. However, previous studies, e.g. Ngambeki, et al. 2002, have shown that farmers have difficulty in distinguishing the causes of disease and pest attack symptoms in banana fields, and hence the remedial measures they take may not serve to alleviate the problems they observe. Baseline information through a participatory assessment is therefore needed of the extent of this problem and whether it applies to some constraints more than others. This will help to focus the project's communication efforts on areas where farmer recognition of constraints and corresponding causes is most lacking. A repeat of this assessment at a later stage will provide a measure of (any) change in awareness and hence will contribute to the success of the promotional phase.

#### **Objectives:**

The objective of the study is to assess farmers' perception/knowledge of constraints that reduce banana yields, establish perceived causes of the constraints, learn about management practices and control measures being used by farmers to reduce the effects of the constraints and identify farmers' knowledge gap in terms of their interpretations of the symptoms and causes of the constraints.

#### **Sampling Procedure:**

The study is to be undertaken in five banana producing districts, namely Luwero, Kayunga, Mukono, Rakai and Ntungamo. In these districts focus group discussions will be conducted. Researchers will visit the districts and hold meetings with key informants with the intention of establishing the most important banana producing sub counties. Two sub-counties in each district will be selected in such a way so as to give a geographical spread and representation of the existing banana based farming systems characteristics. Thereafter, the team will visit each selected sub-county and meet key informants. Parish lists will be developed and 2 parishes will be randomly selected from the sub-county visited. From each chosen parish, two villages will be randomly selected. Two focus group discussions will be held in each village, one with male participants and one with female participants.

#### **Materials and Methods:**

##### *(a) Materials to take to the field*

Manilla sheets, flip chart pens, a bag of bean seeds, a stapler, field checklist, notebooks, laminated pictures of different banana diseases and pests and symptoms showing their effect.

##### *(b) Preliminaries*

In the selected villages, the researchers will meet key informants and explain the purpose of their visit to farmers. Together with key informants, the researchers will solicit the participation of farmers in the village, to have a group discussion about banana production constraints in their



village. The farmers will be congregated in a banana field. The number of farmers participating in each focus group discussion will be limited to 10 – 15 farmers.

*(c) Field Procedure for focus group interviews*

The researchers will facilitate the focus group discussions using a checklist (Annex 1 below) to discuss the identified symptom(s), its causes and to seek farmers' management practices and/or control measures that may be used to manage the problem. The researchers will ask the group to point to a sign or symptom which indicates a problem about a banana plant or bunch within the banana field. The group will also be asked to point to a sign which shows something good about the banana plants or field for purposes of comparison. They will also be asked how they would describe the symptom or sign (e.g. yellowing of leaves).

After a symptom has been identified by a farmer, the group will discuss and agree on what name or phrase will best describe the symptom in the local language. The researchers will probe to find out the perceived cause of the symptoms, e.g. weevils. Note will be made of comments made by the group. The identified symptom will be noted in both the local language and in English, and researchers will take a photograph of the symptom. They will then ask the group about possible control measures they take to deal with the symptom/sign identified, and the source of this information (e.g. other farmers, extension staff). The group will be encouraged to identify further symptoms in the field and the same process will be continued.

Once all bad symptoms have been exhausted in one banana field, the group will be asked whether they have observed any *other* problem symptom in another field in that village. If another symptom is identified, the whole group will move to the banana farm which has that symptom and to continue discussions as before until all bad symptoms identified by the group in that village have been exhausted.

For major banana constraints not present in the banana fields visited, pictures of symptoms of major pests and diseases will be used to facilitate the discussion. Researchers will take notes throughout the discussion. For each symptom the farmers' interpretation of the problem, as well as the researchers' interpretation, will be noted in the facilitators' notebooks and later (in the same day) transcribed to the structured recording sheet (Annex 2 below).

*(d) Assessing farmers' perceptions of seriousness of constraints*

In order, to determine which of the identified symptoms are most serious for banana production, each symptom, *known to the group and observed in the village during this exercise*, will be listed on manilla paper using local language words or a symbol or picture. Next, 20 bean seeds will be placed on the ground and the group asked to allocate a number of seeds out of the 20 seeds, to the **first listed symptom** such that if the symptom was regarded as being highly serious by the group **with respect to its effect (directly or indirectly) on banana production**, it will get 20 bean seeds and if it was considered to be only a very minor problem it will get just 1 seed. The number of seeds allocated will also be written on the manilla paper next to the symptom that was considered. The facilitators will ensure that the group discussion is not dominated by one farmer's views but that all are involved in deciding how many seeds to allocate to the symptom. Comments made by the group during this discussion will be noted by the facilitators.

The process will then be repeated with additional sets of 20 beans (one set of 20 bean seeds for each symptom) until all the listed symptoms have been scored for their level of seriousness. It is important that each symptom is scored out of 20 beans to ensure that the scoring of one symptom is **independent** of the scoring of another symptom. Any comments made by the farmers during this scoring process will be noted by the facilitators in their field note books. The key points recorded in the facilitators notebooks will be transcribed to the field recording sheets (see next page) as soon as possible after the focus group discussion has been completed.

**Data Status:** Information from focus group discussions is still to be collected.

**Data analysis plan:**

(a) Background information concerning the farmers participating in the focus group discussions (FGDs) will be summarised (e.g. by mean values for age, and frequency distributions for others) first to FGD level and then across all FGDs.

(b) Frequency distributions will also be used to summarise information about farmers' perceptions. Agreement/disagreement between farmers' perception of the cause of different symptoms and the researchers' views will be summarised at the focus group level in terms of the proportion (keeping



the numerator and denominator of this proportion separately in the computer sheet) of symptoms that are identified correctly by the farmer.

(c) Scores (out of 20) given to the seriousness of each constraint will fall into an unbalanced data structure since every FGD will not score the same set of constraints. The corresponding data will therefore be analysed using a statistical modelling procedure (e.g. using PROC GLM on SAS).

**Activity related computer files:** <to be included after field work is over>

**List of sub-counties, parishes, villages, farmers:** <to be included after field work is over>

## **ANNEX 1**

### **Checklist for eliciting farmers' perceptions of diseases and pests**

**(Comments made by the farmer group should be noted following discussions on each item)**

1. Ask farmers to point to a sign or symptom in the banana field.
2. Seek group's agreement on a name or phrase that best describes the symptom.
3. Identify farmers' perception of the cause of the symptom.
4. Record symptom in both the local language and in English, and its perceived cause.
5. Ask about control measures the farmers' take to deal with the problem.
6. Ask about the source providing information regarding control measures.
7. Repeat process from item 1 above until all symptoms in the field have been identified.
8. Ask about any other symptoms they have observed in the village. If there are any, move to the farm having that symptom and repeat the process from item 1 above.
9. For constraints not identified above, e.g. weevils, nematodes, black sigatoka, leaf speckle, fusarium wilt, bacterial wilt, banana streak virus, use pictures to repeat the process from item 2 above.
10. Note symptoms observed in the village and known to the group on manilla paper and carry out the scoring exercise for each symptom in turn.



## ANNEX 2

### Recording sheet for eliciting farmers' perceptions of diseases and pests

Main facilitator: ..... Second facilitator:.....

Date: ..... Gender of group:..... Number of people in group .....

Parish and Village (where focus group is being held): .....

#### 1. Details of farmers participating in the FGD:

| Farmer's name (& village if different)  | Age (years) | Education level <sup>4</sup> | Is banana a <b>main</b> crop or <b>secondary</b> crop? | Why banana is grown (food, cash, both) |
|---|-------------|------------------------------|--|--|
| 1.  |             |                              |  |  |
| 2.  |             |                              |  |  |
| etc etc. space available in actual recording sheet to allow details of all participating members to be recorded |             |                              |  |  |

#### 2. Farmers' perception of disease/pest symptoms

(a) Symptoms identified by the farmer in the field (table below to be in landscape for field recordings)

| Farmers' description of sign/symptom of a banana constraint | Farmers' perceived cause of symptom | Management options known to farmer for constraint | Source of information | Scientific interpretation of sign/symptom |
|---|-------------------------------------|---|-----------------------|---|
| 1   |                                     |   |                       |   |
| 2   |                                     |   |                       |   |
| 3   |                                     |   |                       |   |
| 4   |                                     |   |                       |   |
| 5   |                                     |   |                       |   |
| 6   |                                     |   |                       |   |
| 7   |                                     |   |                       |   |
| 8   |                                     |   |                       |   |
| 9   |                                     |   |                       |   |

Additional comments made by the group during discussions

*In the actual recording form, about half-page or 1 page would be kept for comments.*

<sup>4</sup> Education level will be recorded as none, primary, secondary or tertiary



(b) Scoring of seriousness of symptoms identified by the farmers by secret voting

| Symptom of a banana constraint identified by the focus group | Total score given by respondents to symptom |
|--|---|
| 1  |   |
| 2  |   |
| 3  |   |
| 4  |   |
| 5  |   |

Additional comments made by the group during discussions

*In the actual recording form, about half-page or 1 page would be kept for comments.*

(c) Farmers' awareness of symptoms/signs **not** seen on the farm (shown by laminated pictures, e.g. damage symptoms by weevils, nematodes, black sigatoka, leaf speckle, fusarium wilt, bacterial wilt, banana streak virus)

| Pest/disease | Farmers' perceived cause of symptom | Management options known to farmer for constraint |
|--------------|-------------------------------------|---|
| 1            |                                     |   |
| 2            |                                     |   |
| 3            |                                     |   |
| 4            |                                     |   |
| 5            |                                     |   |
| 6            |                                     |   |
| 7            |                                     |   |

Additional comments made by the group during discussions

*In the actual recording form, about half-page or 1 page would be kept for comments.*



## APPENDIX 3

### An activity protocol for an on-farm experimental study

**Activity Title:** Evaluation of improved exotic banana cultivars on farmer fields against pests and diseases and performance with respect to agronomic characteristics and post harvest qualities

**Project Title:** Integrated management of banana diseases in Uganda

**Project Leader:** W. Tushemereirwe

**Activity Leader:** A. Kangire

**Other members contributing to the activity:** K. Nowakunda, D. Ngambeki

**Project funding:** DFID – Crop Protection Programme

**Research partners:** NBRP-NARO, CABI, University of Reading, Natural Resources Institute, U.K.

**Start and end dates:** 2001-2003

#### Background to the activity:

Exotic banana cultivars recently introduced to Uganda have shown promise during on-station trials with respect to agronomic performance and pest/disease resistance. Evaluation of these cultivars under farmer management was needed.

#### Objectives

To evaluate exotic banana cultivars, in particular FHIA 25, PITA8, PITA 14, PITA 17 and SABA, under farmer management with respect to their agronomic performance.

#### Materials and Methods:

*Location:* Bamunanika sub-county in Luwero district.

*Farmers:* Participating farmers were a random sample of 15, drawn from all farmers selected under the sampling structure decided for project activities (Project Protocol gives details).

*Treatment(s):*

- i. Cultivars FHIA 25, SABA, PITA 8, PITA 14, PITA 17, multiplied as tissue culture material and made available to participating farmers. A local control, Kisansa or Mbwarzirume was also included for purposes of comparison.
- ii. Each cultivar appeared on two plots, one mulched and one unmulched. The extent of mulch used was not specified in advance and varied from farmer to farmer. This factor was included because banana productivity is greatly enhanced by mulching through its effect on retention of soil moisture.

*Within-farm location:* In each farm, location of trial plots was agreed with the farmer. All plots were chosen to be as similar as possible to each other, i.e. to be homogeneous. This was to ensure that statistical results were not biased.

*Planting date:* 25<sup>th</sup> April to 25<sup>th</sup> May 2001

*Trial Layout:* 12 plots per farm, i.e. 2 plots, one with mulch and one without mulch for each of the 6 cultivars, laid out as a split-plot experiment with cultivars on main plots and mulch treatment on the sub plot. In each sub-plot, there were 10 mats. Plant spacing was 3m x 3m.

*Experimental design:* A blocked design with farms as the main blocking factor.

*Trial management:* By farmers, but much of the inputs required (other than labour) were provided by the researcher.

*Setting up the trial:*

- a. Scientist and biometrician visited a few farmers, accompanied by one or more technicians, to plan procedures to be followed in setting up the trial within each farm. Later technicians visited the remaining farms and repeated the procedure.
- b. Start and end dates for layout of the experimental plots were 1<sup>st</sup> to 31<sup>st</sup> October, 2000.
- c. Farmer were trained to collect data on bunch weights, harvest date, flowering date, sucker emergence date, for every plant in every research plot.



#### *Trial monitoring:*

- a. Each farmer was visited once a fortnight by the Field Assistant (FA) to check progress and maintenance of the trial by the farmer. The FA ensured that the farmer fully understood requirements concerning data collection.
- b. FA at regular intervals of time, transcribed farmer records to FA's data collection sheets during visits to the farm.
- c. On the first Monday of each month, FA visited KARI to deliver data collection sheets to the scientist. A second (duplicate) copy of the data collection sheets was then taken by the FA to continue with further data collection.

**Data collected:** (Measurements are listed briefly here. The actual protocol has further details).







*Farmer records at harvest:* date of harvest, bunch weight, number of clusters, number of leaves.

*Researcher records at flowering time:* Flowering date, number of plants per mat, girth at 1 metre, height of plant, number of leaves at flowering, number of the youngest leaf spotted (for black sigatoka assessment) and nematode assessments.

**Data status:** Data collection was completed up to 1<sup>st</sup> cycle. Data were computerised and checked for errors. The data have been included in the project archive.

**Data analysis plan:** <This was not written during the study, but if written would have greatly facilitated the subsequent analysis process. It would have included identification of the specific objectives of the analysis, listing variables to be used, noting steps needed to organise the data into the right format for analysis, and an indication of the type of approach to be undertaken during the data analysis and the software to be used>

#### **Activity related computer files:**

| Name ▲   | Size   | Type                   | Date Modified    |
|--|--------|------------------------|------------------|
|  L_EV_Analysis  |        | File Folder            | 11/04/2004 18:23 |
|  L_EV_Protocol_AK2.doc                                  | 48 KB  | Microsoft Word Doc...  | 11/04/2004 18:42 |
|  L_EV_Growth_cycle1_Jul03.xls                           | 345 KB | Microsoft Excel Wor... | 02/03/2004 09:19 |
|  L_EV_NEMATODES_YR_02.xls                               | 59 KB  | Microsoft Excel Wor... | 02/03/2004 09:48 |
|  L_EV_Plot&Plant_Nos.doc                                | 53 KB  | Microsoft Word Doc...  | 29/02/2004 05:29 |
|  Protocol for weevil and nematode damage assessment.doc | 23 KB  | Microsoft Word Doc...  | 18/11/2003 09:34 |

**List of farmers:** <The actual protocol included a list of farmers who participated in the trial>



## APPENDIX 4

### An activity protocol for an on-station experimental study

- Activity Title:** The effect of crop management on BSV disease expression and crop performance.
- Project Title:** Epidemiology, vector studies and control of *Banana streak virus* in East African highland bananas
- Project Leader:** Dr. W. Tushemereirwe
- Activity Leader:** C. Murekezi
- Other members contributing to the activity:** Dr. T.R. Wheeler, Dr. S.R. Gowen, L. Kenyon, J. Muhangi and J. Katongole
- Project funding:** DFID – Crop Protection Programme
- Research partners:** NBRP-NARO, CABI, University of Reading, NRI
- Start and end dates:** 2001-2003

#### Background to the activity:

Banana streak (BSV) virus disease is a serious banana constraint in Uganda. Climatic conditions are observed to influence disease symptom expression. Preliminary reports indicate BSV symptom expression and banana yield are influenced by crop management in that good crop management practices mitigate the effects of BSV. This activity aims at obtaining empirical data on the effect of climate on disease and whether good management alleviates disease effects restoring yields to near normal.

#### Objective of activity

Assess the effect of crop management and climate on BSV incidence, severity and crop performance.

#### Materials and Methods:

**Location(s):** Kawanda Agricultural Research Institute, Kampala, Central Uganda and Mbarara Stock Farm, Mbarara, south western Uganda. Mbarara zone has been reported to have high BSV incidence (Tushemereirwe *et al*, 1996).

#### **Treatment(s):**

- i. Crop management regimes: **optimal management** comprised application of mulch (10 cm thickness), fertilisers (150 kg N, 25 kg P and 200 kg K ha<sup>-1</sup> yr<sup>-1</sup>; McIntyre, per. comm.), and routine weeding, and **minimal management** comprised no mulch or fertiliser, but had 2 episodes of weeding during a single crop cycle. Crop management practices have been reported to mitigate the effects of banana diseases like black sigatoka, and to improve soil nutrition (mulch and fertilizer). Weed control is also an important management practice as weeds are reported to be very limiting to crop production. It was on this basis that these aspects of crop management were chosen as treatments in this experiment.
- ii. Cultivars: Cavendish 'Williams', an exotic dessert banana, and Mbwazirume, which is an East African Highland cooking banana, propagated from tissue culture appeared in three subplots. Initially, cultivar Mbwazirume was classified into BSV positives and BSV negative status based on ELISA tests of the parent plants from which they were propagated using tissue culture. Subsequently, Cavendish, Mbwazirume ELISA positive and negative tissue culture plants were randomly assigned to the three plots. ELISA tests, though, were unreliable and plants with and without BSV symptoms were observed in plots of either BSV status. Therefore, the two plots of Mbwazirume were considered as repeats of the same cultivar. Mbwazirume was selected as a treatment in the experiment because it has been observed to have high BSV severity. It has been reported that sequences integrated in the genome of Cavendish-AAA are not activated to episomal forms of BSV. So BSV observed in Cavendish would imply that BSV would be transmitted by mealybugs. Hence, Cavendish acted as a check for transmission of BSV.



*Planting date:* October 2000 and November 2000 in Kawanda and Mbarara, respectively.

*Experimental design:* Optimal and minimal crop management regimes and cultivars were laid out as a split-plot experiment, with crop management as main plots and cultivars as sub plots, replicated 4 times. In each plot, there were 42 mats, 20 mats (four rows of five mats spaced 3m apart) forming the data plants and the rest border row plants. Gross plot size was 18 x 15 m<sup>-2</sup>. For effective data collection the experiment had to be kept to a size that was manageable, therefore, a split plot arrangement was adopted. In this case, effects due to crop management were determined less precisely. This was justifiable because the effects due to crop management were more pronounced.

*Trial management:* Across the entire experiment, weevils were controlled by spraying with contact pesticides bi-monthly. Removal of dead leaves, sheaths and cutting up harvested pseudostems to hasten drying, denying weevil breeding conditions for weevils, was done bi-weekly, removal of excess suckers was done routinely and corms of harvested plants were uprooted annually. Weevils are known to affect banana performance and cause yield loss. Dead sheath and leaves create an environment for disease and interfere with light interception. These were managed to exclude their effects in the experiment.

*Setting up the trial:*

- i. Activity Leader and contributing members to the activity planned the trial design and procedures to be followed in setting up and running the experiments. Later Activity Leader and technicians set up the experiments at Kawanda and Mbarara.
- ii. The Activity Leader trained technicians on how to collect data on bunch weights, harvest date, flowering date, sucker emergence date, plant height and circumference of pseudostem at 1 meter, disease symptom severity, and leaf emergence for every plant; and soil bulk density, soil and foliar samples for each plot.












*Data collection:*

Activity Leader and technicians collected data on soil water weekly at Kawanda only. The rest of the parameters were collected at Kawanda and Mbarara. These were: leaf emergence, climatic data, disease severity and soil temperature, collected monthly. Bulk density and soil sampling was done at the beginning and at end of experiment. Soil sampling was done for each crop cycle. Bunch weights, harvest date, flowering data, sucker emergence date, plant height and circumference of pseudostem at 1 meter data was collected weekly after the parent crop was harvested. These variables are justified in Box 3 of the main document of this manual.

**Data status:** Data collection completed up to 2<sup>nd</sup> cycle.

**Name of activity related computer files:** (Only Kawanda files are shown. Mbarara was similar)

*b1. BSV(R7529)\ClimateStree&YieldLoss\_CM\Kawanda*

|   |        |                        |                  |
|---|--------|------------------------|------------------|
|  K_CISt_BulkDen_1stYear.xls    | 23 KB  | Microsoft Excel Wor... | 18/11/2003 09:34 |
|  K_CISt_BulkDen_baseline.xls   | 256 KB | Microsoft Excel Wor... | 19/01/2004 09:08 |
|  K_CISt_Gr&Yld_climate00.xls   | 55 KB  | Microsoft Excel Wor... | 21/01/2004 07:27 |
|  K_CISt_Gr&Yld_climate01.xls   | 54 KB  | Microsoft Excel Wor... | 21/01/2004 07:27 |
|  K_CISt_Gr&Yld_climate02.xls   | 52 KB  | Microsoft Excel Wor... | 21/01/2004 07:29 |
|  K_CISt_Gr&Yld_parent.xls      | 447 KB | Microsoft Excel Wor... | 21/01/2004 07:37 |
|  K_CISt_PlantNut_1stRatoon.xls | 15 KB  | Microsoft Excel Wor... | 18/11/2003 09:34 |
|  K_CISt_PlantNut_parent.xls    | 17 KB  | Microsoft Excel Wor... | 18/11/2003 09:34 |
|  K_CISt_SoilNut_1stYear.xls    | 20 KB  | Microsoft Excel Wor... | 21/01/2004 07:36 |
|  K_CISt_SoilNut_baseline.xls   | 18 KB  | Microsoft Excel Wor... | 21/01/2004 07:33 |
|  K_CIStr_Gr&Yld_1st ratoon.xls | 513 KB | Microsoft Excel Wor... | 21/01/2004 07:24 |



## Appendix 5

### An activity protocol for a laboratory study

**Activity Title:** Effect of soil amendments in the delivery of *Beauveria Bassiana* for the control of the banana weevil

**Project Title:** Integrated management of the banana weevil

**Project Leader:** Dr. Caroline Nankinga

**Activity Leader(s):** Magara Evarist

**Other members contributing to the activity:** Helen Pedum (technician)

**Project Funding:** DFID – Crop Protection Programme

**Research Partners:** University of Reading, UK., IITA, CABI, Nairobi

**Start and end Dates:** April 2001 – March 2004

#### Background:

Recent studies indicate that the entomopathogenic fungus, *Beauveria bassiana* has a high potential as a biological control agent for the banana weevil in Africa. However, the biotic and abiotic factors that may influence the efficacy and persistence of this fungus under field conditions are not yet fully evaluated. Therefore, this activity aims at evaluating the efficacy and persistence of various *B. bassiana* formulations under laboratory conditions and evaluating the most effective formulation for use in subsequent field experiments.

#### Objectives:

To study the infectivity of different *B. bassiana* formulations to the banana weevil (*Cosmopolites sordidus*). More specifically to determine the amount of conidia produced from different *B. bassiana* substrates and to evaluate the infectivity of different *B. bassiana* formulations against the banana weevil under laboratory conditions.

#### Materials and Methods:

*Location:* Banana nematology/weevil laboratory, Kawanda

*Source of materials:*

| Material                     | Source   |
|------------------------------|--|
| Cracked maize and maize bran | Kawempe maize mill   |
| Bagasse                      | Lugazi sugar works   |
| "Machicha"                   | Kawanda malwa (local brew) joint   |
| Cotton husks                 | Kawempe ginnery  |
| <i>B. bassiana</i> inoculum  | lab. reserved conidia, continuously recultured, and kept in the fridge at 4°C.                               |
| Banana weevils               | parent stock collected from Masaka District, then reared in metallic drums in a shade outside the laboratory |
| Spent yeast                  | Uganda Breweries   |
| Sucrose (sugar)              | Purchased from retail shops  |
| Clay and loam soils          | KARI swamp and field respectively  |

*Preparation of experimental materials and data collection*

(a) *B. bassiana* spore (conidia) counts

METHOD (Ref: Insect Pathology Manual (1997) Edited by C.H. Lomer)

➤ 1g of fungal substrate weighed into a test tube



- Mix with 100 ml of distilled water, then add 2 drops of liquid soap
- Let the solution settle for about 10 minutes
- Shake and mix thoroughly
- Measure out 1 ml and mix it with 9 mls of distilled water ( $= 10^{-1}$  dilution)
- Using a dropper to introduce one drop into the counting chamber
- Count the spores in the 5 diagonal big squares, in the 2 grids
- Finally use the formula  $C=A \times 5 \times 10^4$ , where C is the concentration of spores/ml in the diluted quantity and A is the average spore counts from the 2 grids
- The concentration of spores in the original solution before dilution:  
 $S= C \times 10^n$  where n is the number of dilutions, i.e.  $S=A \times 5 \times 10^4 \times 10^n$ .

#### (b) Banana weevil rearing

The initial batch of banana weevils were trapped from KARI and farmers' banana plantations in Masaka using split pseudo stem traps. The weevils were reared in metallic drums on fresh banana corms under a shade as described by Nankinga (1999). The adult weevils were introduced to pared banana corms to oviposit eggs for seven days and thereafter the banana corms were maintained in metallic drums for 60 days to allow development of eggs to adults. The drums were covered with papyrus mats to avoid desiccation.

#### (c) *B. bassiana* culturing and formulation

One strain of the fungus, code G41, known to have high pathogenicity to *C. sordidus*, superior growth and sporulation was used. It was cultured in KARI insect pathology laboratory on the substrates under evaluation; cracked maize, maize bran, "machicha", cotton husks, bagasse, cotton husks + maize bran, maize bran + bagasse and bagasse + spent yeast. The substrates were cultured following the modified diphasic method described by Nankinga (1999). Where substrate mixtures were made, this was done to the ratio of 1:1 by volume.

"Machicha" is spent millet and yeast residue obtained after a local potent gin ("malwa") has been extracted. This was collected from the local drinking places, washed, dried and used for culturing the fungus. The amount of conidia produced in each gram substrate was determined using the improved Neubuer Hemacytometer counting chamber (0.100mm deep), as described in the section on spore counts<sup>5</sup>.

#### (d) Formulations for Laboratory bioassays

The formulations evaluated were *B. bassiana* grown on cracked maize seed, maize bran and "machicha", applied alone or formulated with loam soil or clay soil. The formulations were chosen depending on their conidia yields. The loam soil was collected from the banana field at KARI with the physical characteristics of estimated levels of sand (52%), silts (28-50%), clay (7-28%), and high water holding capacity (23%). The clay soil used was the grey type, mined from water logged swamps, with particle size of approximately 0.002 mm. Thus, eleven (11) *B. bassiana* formulations were evaluated under laboratory conditions and these are;

- Maize bran alone, maize bran + loam soil, maize bran + clay soil
- "Machicha" ("bussa") alone, "machicha" + loam soil, "machicha" + clay soil
- Cracked maize alone, cracked maize + loam soil, cracked maze + clay soil
- Loam soil alone or clay soil alone with nothing added.

The *B. bassiana* grown on cracked maize substrate was used as the standard. 1g of this substrate was mixed with 1g of the sterile formulation (1:1 ratio). The 2g was then weighed into plastic petri-dishes and replicated 3 times. The amount of conidia in each treatment was standardized to the same level as in cracked maize. The amounts of the other substrates used depended on the amount of conidia per gram determined. They were also in the ratio of 1:1 per formulation.

#### Key dates associated with the trial:

(a) *B. bassiana* culturing and conidia counts: 29/11/01 - 20/05/02.

(b) Laboratory tests for the different *B. bassiana* formulations: 24/05 - 24/06/02.

---

<sup>5</sup> The full protocol included the corresponding details



#### Experimental treatments:

- (a) No. of substrates = 8 (for objective 2i above); these are; Cracked maize, Maize bran, "Machicha", Cotton husks, Bagasse, Cotton husks + maize bran, Maize bran + bagasse, Bagasse + spent yeast.
- (b) No. of formulations = 11 (for objective 2ii above) and these are; Clay soil alone, Loam soil alone, Cracked maize + clay, Maize bran + clay, "Machicha" + clay, Cracked maize alone, Maize bran alone, "Machicha" alone, Maize bran + loam, Cracked maize + loam, "Machicha" + loam soil.
- (c) No. of replicates per formulation = 3; for each experiment.
- (d) No. of weevils per replicate = 10 of mixed sex (1:1 ratio).

#### Experimental design:

Completely randomised design (CRD), since the laboratory area used was uniform. First the treatments were allocated to petri-dishes at random. An area measuring 1x1m was marked on the laboratory bench. The positions for placement of petri-dishes were marked on the bench and each petri-dish randomised to marked positions, using a table of random numbers.

#### Data to be collected:

##### Measurements:

- (a) amount of conidia per unit gram of substrate.
- (b) weevil mortality in the different formulations.

The numbers of dead weevils were recorded at different time points i.e. by observing the weevils after every 5 days for mortality, over a 30-day period. Any dead weevils were removed, and put into a moist chamber and observed for any *B. bassiana* fungal growth.






**Data Management:** <Not included here, but would include a description of how data will be computerised, organised and managed and plans for data analysis procedures, together with lists of data file names and other documentation.>

**Data Status:** All data were computerised immediately after the experiment was completed. Data checking then took place.

#### Data Analysis Plan:

Statistical analysis will use the SAS package. Analysis of variance procedures will enable treatments to be compared and specific comparisons of interest will be made using the estimate statement in SAS PROC GLM.

#### Activity related computer files:

| Name ▲   | Size   | Type                      | Modified         |
|--|--------|---------------------------|------------------|
|  K_Attractiveness_kairomones_buried_tissues.xls       | 32 KB  | Microsoft Excel Worksh... | 14/01/2004 06:59 |
|  K_Bb_Formulations&SoilAmendmentsLabPot.xls           | 117 KB | Microsoft Excel Worksh... | 14/01/2004 08:14 |
|  K_Dissemination_Inoculated_noninoculated_weevils.xls | 42 KB  | Microsoft Excel Worksh... | 14/01/2004 06:59 |
|  K_Dissemination_lab_trap_infection.xls               | 89 KB  | Microsoft Excel Worksh... | 28/02/2004 11:34 |
|  K_Pilot_tests.xls                                    | 47 KB  | Microsoft Excel Worksh... | 03/03/2004 11:19 |

**Protocol filename:** *Protocol\_SoilAmendments\_Lab\_ME1.doc*



## APPENDIX 6

### An activity protocol for a survey investigation

**Activity Title:** Determinants of resource allocation in low input agriculture: *The case of banana production in Uganda*

**Project Leader:** Dr. W. Tushemereirwe

**Activity Leaders:** F. Bagamba, R. Ruben, A. Kuyvenhoven and J. Ssenyonga

**Other members contributing to the activity:** R. Kalyebara, E. Kikulwe, Y. Mulumba and W. Tumusiime

**Project funding:** Rockefeller foundation

**Research partners:** IFPRI and INIBAP

**Start and end dates:** 2003-2005

#### Background to the activity:

Banana production provides suitable options for subsistence and income generation in the mid and high elevation areas of East Africa, including Uganda. Limited access to factors such as markets (labour, land and credit), as well as critical biophysical factors (pests, diseases and soil degradation) have led to the decline of banana production in central Uganda. However, there has been a rise in production in south-western Uganda. A bio economic model is formulated within a household theoretic framework to analyze the impact of price and technology change on banana production. Findings have implications for policies to support sustainable agricultural production and growth, contributing to on going debates about the separation of consumption and production decisions in developing economies and the response of poor households to price incentives.

#### Objectives of activity

- (i) Determine household and farm characteristics that influence banana production Uganda
- (ii) Construct a bio economic model to analyse resource allocation by farmers in Uganda
- (iii) Evaluate the impact of new banana types, commodity prices and factor prices on banana production
- (iv) Assess the impact of introduced new improved varieties.

#### Materials and Methods:

*Location:* Sub-counties in eastern, central and southern Uganda

#### *Sampling Procedures:*

A detailed sampling protocol was written for this survey, based on a stratified, multi-stage random sample. The process is described in brief below.

Two types of strata were considered in the sampling, "exposed" and "not-exposed" areas, and areas of low and high elevation. Here "exposed" refers to areas where improved planting materials (banana suckers) had been introduced. In accordance with available resources, 24 sub-counties were selected from all districts in central, eastern and southern Uganda. Sub-counties in the three districts were first mapped into the 4 strata, i.e. (i) low elevation, with exposure; (ii) low elevation, without exposure; (iii) high elevation, with exposure, and (iv) high elevation, without exposure. The number of sub-counties to choose from each stratum was decided according to proportional allocation, so that in total, 24 would be chosen. These were selected at random from all sub-counties in that stratum.

At the next stage of sampling, one parish was chosen at random from each sub-county, and then one village from that parish, also chosen randomly. In each selected village, 20 households were then randomly selected, resulting in a total sample of 480 households.

Additional sub-counties were also selected purposively to represent the benchmark sites of the National Banana Research Program. The sub-counties selected were Bamunanika sub-county in



Luwero district, to represent areas with a decline in banana production; Kisekka sub-county in Masaka district – representing relatively high production but with incipient decline; and Ntungamo – representing relatively high and stable production. Three parishes were also randomly selected from each of these three sub-counties and one village selected randomly from each parish, giving a total of 9 villages from the three benchmark sites. From each of these villages 20 households were randomly selected giving a total of 180 households.

The two sampling procedures above thus led to 33 villages with 20 households drawn from each, giving a total of six hundred and sixty households.

**Data collected:**

- Village level data include elevation, location, wage rates, price and road access.
- Household data included demographic characteristics, labour (farm and off-farm), household expenditure, production and income.
- Data collected from farm plots were crop and animal production characteristics. In addition to these, data on soil fertility, moisture levels and slope were collected to answer how bio-physical constraints affect household resource allocation.
- Above data were captured in a series of 10 questionnaires<sup>6</sup>, pilot tested prior to data collection.

The data collection began with the single visit schedules in April 2003 and proceeded with monthly schedules, thereafter. Monthly data will end in April 2004.

**Data status:** Data collection is nearing completion

**Data analysis plan:** <Not included here>

**Activity related computer files:** <not included here>

---

<sup>6</sup> The 10 questionnaires corresponded to (a) household; (b) cultivars; (c) banana plot; (d) general plot A; (e) general plot B; (f) Expenditure-Income single visit; (g) Expenditure-Income monthly visits; (h) Labour – single visit; (i) Labour – monthly visits; (j) Banana Production – monthly.



## APPENDIX 7

### File structure for DFID Crop Protection Research Programme funded cluster of banana projects

- [-] DFID\_CPP
  - [-] BSV(R7529)
    - + ClimateStress&YieldLoss\_CM
    - + Epidemiology\_JK
      - Ntungamo\_30farmSurvey\_CM&JK
      - Physiology\_CM
    - + Proposal&ProgressReports&FTR
    - + Reports&Protocols
    - Socio-economics
  - [-] DataMgt(R8301)
    - Admin
    - FinalProposals
    - + Guidelines&StrategyMtgs
    - InitialProposals
    - NARO Sept Conference
    - + ResearchDataMgtWorkshop
    - ScopingStudyVisit
    - TraineesReports
    - VisitReports
  - [-] IPM(R7567)
    - FTR\_CD
    - + Luwero
    - + Masaka
    - + Ntungamo
    - ProjectProposal&Planning
    - + Reports
    - + UK based work
  - + Promotion(R8342)
  - [-] Weevil(R7972)
    - + Lab&Pot\_Expts
    - + On-farm field
    - + On-station field
    - + Report&Protocols



# **Guidelines and Procedures for Effective Data Management**

## **PART II**

### **Resource Materials on Data Management**



# DEVELOPING A DATA MANAGEMENT SYSTEM FOR THE NATIONAL BANANA RESEARCH PROGRAMME (NBRP), UGANDA

## 1. Background

Data management issues have been a primary concern to the National Banana Research Programme (NBRP) in Uganda for several years, following difficulties faced when attempting to produce results from the NBRP Diagnostic Survey. Many further data collection activities have taken place since then and as the range of projects within the NBRP increases, so does the need to have a system in place for managing the data effectively, avoiding duplication of effort in data collection and computerization work across the numerous studies undertaken, and ensuring ready access to comprehensible and usable data. The most interesting analyses in the future are likely to be those that integrate data from different component studies, and this will certainly require high quality data management and the availability of a properly maintained database management system.

Our expectations are that such a system will

- (i) provide the means to get data in,
- (ii) ensure data are of good quality,
- (iii) hold every observation and the associated “metadata” (What? When? Where? Who? Why and How? information, and other notes),
- (iv) allow these to be retrieved for scrutiny,
- (v) allow analysis datasets to be selected and synthesised from the input files.

Within NBRP, there is currently no data management strategy in place which will allow all the information from experimental trials, surveys, participatory approaches, etc, to be centralized for easy access by research managers and scientists responsible for individual projects within NBRP. This proposal aims to provide NBRP with an effective data management system with support from the Research Support Unit at the International Centre for Research in Agro-Forestry (ICRAF) in Nairobi, and the Statistical Services Centre (SSC) at The University of Reading in the UK.

ICRAF staffs have already made major strides towards a data management system which handles a wide range of study and data types, i.e. through conceptualizing and developing a software tool known as **Logbook**. It would seem appropriate to use Logbook to incorporate all existing NBRP data and enable a flexible system for capturing information from all NBRP’s data collection activities.

SSC currently hold a DFID funded project (R8301) to support initial activities that would help in the development of a database management system for NBRP. The expected outputs from this project are:

- (a) Archiving, at the National Agricultural Research Organisation (NARO) in Uganda, of all raw data, meta-data and study protocols, as well as reports available by December 2003, for the CPP-funded cluster of banana projects, i.e. projects R7567 (IPM), R7529 (BSV) and R7972 (Weevils).*
- (b) Setting up guidelines and procedures, necessary for maintaining a good database management system, and documenting these in consultation with NBRP staff, with the work facilitated through staff training in basic principles of research data management.*
- (c) Developing and documenting an appropriate data management strategy for all NBRP research activities, which will be accepted by NBRP staff and collaborators.*

In the DFID proposal above, it was stated that the success of (c) above would depend on Rockefeller or other funding being available for additional supportive inputs by a database expert. We see this assistance being provided by Peter Muraya at ICRAF, through a one-week workshop for NBRP research staff on the general principles and benefits of Logbook, to demonstrate requirements for getting Excel data files in a form compatible with the Logbook structure, and to discuss with NBRP staff, requirements for setting up a good data management strategy. The latter work will be done jointly with SSC as per (c) of the DFID project above.



We see this support from ICRAF as a component of the first stage of the current proposal for Rockefeller funding. NBRP scientists have already had a 4-day training programme in Research Data Management under activities of the above mentioned DFID project, but the latter only progressed to the point of ensuring that scientists are aware of basic data management tasks and to help them ensure data quality through more effective use of Excel for data validation and data management. Now that NBRP staff have been sensitised to data management issues, it is time to move forward into developing a proper data management system for all NBRP activities. This will provide an unparalleled data resource for banana. It will also develop a schema that can readily be handed over to other NARS banana researchers elsewhere. It seems likely that any work required after three years of this project can be undertaken in Africa, by Ugandans and Kenyans.

Another component of the first stage is to ensure that the documentation is available so that scientists can begin to get new data sets in a form that can be readily transferred into Logbook. Currently SSC's Senior Computing Adviser is preparing the first draft of documentation for Logbook users. This initial work is being funded by ICRAF, but the documentation will need modification to suit the requirements of the banana programme, and pilot tested with NBRP scientists. This proposal therefore includes a component of activities to be carried out by SSC to develop the documentation appropriately for use by banana researchers.

Three persons within NBRP have already been identified as key personnel to be involved in helping to develop and maintain a data management system for NBRP. They need training to ensure long-term sustainability of the system

The first person is **Allan Rwakatungu**, a Research Assistant, serving within the Biometrics Unit at KARI. Rwakatungu has a B.Sc. in Statistics and Economics, but his interests are in information technology. On his own initiative, he has taught himself some basic principles of web-based design, and has developed a simple web-page for NBRP. He is therefore an appropriate person to assist NBRP researchers in maintaining and improving a database developed for NBRP activities. He has currently no formal computing training, but is very keen on developing skills in this area.

The second person relevant to database work is **Hussein Kisingo**, currently attached to IITA and serving as their database manager at Kawanda. Kisingo also has only a first degree, but through self-taught means has developed some experience in databases and general computing aspects. He is also in need of some more formal training in information technology and is expected to have primary responsibility for maintaining a database for NBRP work and also provide guidance to Rwakatungu in the coming years.

The third person is **Yusuf Mulumba**; a research assistant responsible for data management for the DFID supported projects. It is expected that Kisingo, Rwakatungu and Mulumba will be key players in the future management of a database for NBRP. However, the processes involved in getting NBRP data organized for Logbook needs a high level of expertise, as can be provided by Peter Muraya at ICRAF. This work can commence after data from several NBRP projects have been documented in a systematised way. The latter work is currently underway within the DFID funded project R8301.

It is suggested that database development work on a Banana Logbook is undertaken in close collaboration with Kisingo, Mulumba and Rwakatungu, who are both very familiar with research activities undertaken by the NBRP researchers. They would learn from Muraya about Logbook development work and together tune Logbook to suit UNBRP's requirements.

This proposal therefore sees the second stage of database activities beginning with some training by Peter Muraya for Kisingo, Rwakatungu and Mulumba on Logbook concepts and development ideas, and developing the existing Logbook structure to a form more suited for work within NBRP. This will enable them to develop a "Banana Logbook" and begin work on transfer of banana project data into the Logbook. However, concentrated effort on organising banana data and transfer to Logbook will require on-hand expert help. This support will be provided by SSC.



This proposal envisages the development and testing of a Banana Logbook system for NBRP and transfer of data from at least five relatively large projects into the Banana Logbook system. It is expected that the Biometrics Unit staff will then have the necessary skills to continue putting data from all other banana projects into Logbook.

There are however two other areas (not included in the costings of this proposal) which need attention to complete an effective system and to get the researchers on board with using this system. They both involve further components of training.

First, Kisingo, Mulumba and Rwakatungu need to be trained to get a full understanding of Logbook's underlying structure and develop their skills in modifying Logbook further to suit changes in banana research requirements over time. For example, some further programming work is likely to be needed on making data retrieval easier. Currently Logbook allows data to be accessed automatically in just one way by writing the relevant query. For data access in different formats, further queries need to be set up. Once the common data retrieval demands of NBRP are determined, it would be possible to set up further automatic queries to assist the retrieval process.

Secondly, requirements of the help system from the users' point of view must be identified and addressed. Here there is an argument for getting together both scientists with experience in banana research and statisticians, so that the specific user requirements can be identified, from the point of view of scientific interests, quality control checks, and statistical analysis. For example, statisticians together with a number of scientists from NBRP and outside can undertake this component of the work and also carry out an independent review to assess the validity of the Banana Logbook in quite different settings, posing real demands on the system outputs. Help can also be provided in preparing appropriate documentation and training course material for potential users of the Banana Logbook to a high standard in reasonable time. The training material will need to be tested through a user training workshop for banana researchers, and subsequently updated.

The above two components have not been included in the current proposal, but we expect to seek DFID or other donor support for these activities in due course.

## **2. Objectives**

The overall objective is to develop a "Banana Logbook" – a flexible tool for management of research data within the Uganda National Banana Research Programme. It will involve joint efforts between NBRP staff, the Research Support Unit at ICRAF in Nairobi, and the Statistical Services Centre (SSC) at the University of Reading in the U.K.

Specific objectives to be achieved in years 1 and 2 of this project are given below. These objectives will lead to a Banana Logbook, developed in close collaboration with three key computing personnel, based at Kawanda Agricultural Research Institute, so as to ensure local ownership of the final product.

A second objective will be capacity building for the computing personnel as well as for research scientists to help them to enhance the quality of their research outputs.

### ***Specific Objectives for Year 1:***

1.1. Development and documentation of a Data Management Strategy for NBRP, in joint association with the on-going DFID-funded project (R8301) on archiving of data for the DFID-funded cluster of banana projects and associated training for NBRP research staff on basic principles of data validation and data management.



1.2 Organising data from one banana project for input into Logbook and using this (a) to raise awareness amongst banana researchers of the potential benefits of the Logbook system for managing their research data, and (b) to provide training on the Excel data formats required for easy transfer of data into Logbook.

1.3. Further develop, modify, improve and pilot test the documentation for a “Banana Logbook”.

1.4. Hussein Kisingo and Allan Rwakatungu locally trained to receive a Diploma in Information Systems Management, and a Certificate in Desktop Visual Basic, via evening and Saturday courses in Kampala

### ***Specific Objectives for Year 2:***

2.1. To achieve the final version of the “Banana Logbook” with appropriate training of key computing personnel and incorporating data from at least 5 banana research projects into the Banana Logbook.

## **3. Activities**

### ***Activities in Year 1:***

The activities for year one will start from 01 January 2004. It is expected that items 1.1 to 1.6 below will take place during a two week period in April 2004.

1.1 Organising data from one (relatively large) banana research project within Logbook, with support from ICRAF (one week).

1.2 Three-day (2 days on Logbook training, 1 day on finalizing strategy) training workshop for NBRP research staff to expose them to the benefits of what can be achieved with Logbook and to demonstrate requirements of data formats for input into Logbook. The workshop will also include discussions with the research staff about the requirements of a good data management strategy for NBRP, and will be done jointly with SSC.

1.3 Concurrently with the above activity, updating, modifying and pilot testing the documentation on the use of Logbook to suit NBRP requirements. (This work will be undertaken in Uganda by Cathy Garlick of SSC).

1.4 Documentation of a Data Management Strategy for NBRP, in consultation with, and acceptable by, senior staff of NBRP. (This will be done largely by SSC with DFID funding, with support from NBRP and in conjunction with ICRAF’s involvement in 1.2 above).

1.5 Two days support from ICRAF for activities 1.3 and 1.4 above.

1.6 Training in Information Technology (local 1-yr Diploma in Information Systems Management, and a 40-hour course on Visual Basic) for Hussein Kisingo and Allan Rwakatungu, so as to provide necessary support to NBRP in assisting in the preparation and subsequent maintenance of the database management system.

1.7 Research staff implement their training knowledge on good practice in data management tasks on two computers specially dedicated for work on data management, following activities in 1.2 above. This work will be supervised and supported by Hussein Kisingo, Allan Rwakatungu and Yusuf Mulumba.



### ***Activities in Year 2:***

2.1 Hussein Kisingo, Allan Rwakatungu and Yusuf Mulumba trained by Peter Muraya at ICRAF, in concepts and development ideas of Logbook and tuning Logbook to NBRP requirements to complete the first version of a “Banana Logbook” (12 days x 3 persons, plus 14 days for Muraya, i.e. 2 days preparatory work, 10 days training, 2 day of follow-on support).

2.2 Kisingo and Rwakatungu, with help from statistician Mulumba, prepare Excel files for all data related activities of **two** banana projects, assisted via e-mail by Muraya.

2.3 Further development work on the Banana Logbook, undertaken by Kisingo, Mulumba and Rwakatungu, using data from the projects in 2.2 above.

2.4 Kisingo and Rwakatungu, with help from statistician Mulumba, prepare Excel files for all data related activities of **three more** banana projects and transfer them to Logbook.

2.5 SSC member will visit for another one week to ensure data from 2.4 above have been effectively included within Logbook. On-site training for the Biometrics Unit staff on efficient use of Logbook will also be provided and documentation on use of the Banana Logbook improved.

## **4. Budget (in US dollars)**

Costings for this proposal are given at the end of this document in detail. A summary appears below. Please note that in addition to the development of an effective database management system for NBRP, the costs also include a large training element. Much of the external consultancy inputs are related to assistance to local staff on Logbook developments and training for them as well as for NBRP research staff..

### **COSTING FOR THE NBRP DATA MANAGEMENT PROJECT: BUDGET SUMMARY (US \$)**

| Item                               | Year 1 US\$   | Year 2 US\$   | Total US\$    |
|------------------------------------|---------------|---------------|---------------|
| Consultancy fees                   | 11,200        | 10650         | <b>21850</b>  |
| International travel               | 5,300         | 10350         | <b>15650</b>  |
| Consumable and local travel        | 2,000         | 4,659         | <b>6,659</b>  |
| Local training                     | 5,000         | -             | <b>5,000</b>  |
| Administrative costs and utilities | 2,000         | 2,000         | <b>4,000</b>  |
| Capital equipment                  | 6,000         | -             | <b>6,000</b>  |
| Salaries                           | 4,800         | 10,200        | <b>15,000</b> |
|                                    |               |               |               |
| <b>Grand Total</b>                 | <b>36,300</b> | <b>38,709</b> | <b>74,159</b> |



## Appendix 9 (Part A)

### Feedback on current the status of data management

At the workshop on *Tools and Methods for Data Management*, a short overview of the status of Data Management within NBRP was given at the request of the organisers. A very brief sketch was given of how project R8301 began and the achievements during the project. However, it was thought more appropriate to seek the participants' own views of the project's impact. They were therefore presented with three separate sets of questions for discussion and presentation. Boxes 1, 2, 3, 4 present the questions and the flip-chart summaries, together with some additional comments. Participants were given only about 15 minutes for discussion and 5 minutes for presentation.

#### Box 1. Questions put to Scientists, research assistants, technicians (GROUP 1 – about 6 members)

Discuss and report back on

- (a) your views on *current strengths* and *weaknesses* within the banana programme with respect to data management
- (b) your recommendations for the future with respect to data management.

##### **Flip-Chart Presentation:**

##### *Strengths:*

- Improvement in data sheet design
- Systematic creation of directories and sub-directories for data storage
- Application of data validation techniques
- Inclusion of meta-data
- Data archiving (centralised storage)

##### *Weaknesses:*

- Imperfect data sheets (*presenter commented that when it came to data entry, problems still existed*)
- Raw data storage
- Duplicate files cause problems (*presenter commented that due to shortage and sharing of computers, updates to data and other files were kept on different computers, leading to duplicates and some confusion about which files had different modifications done*).
- Failure to detect errors (*presenter commented that they still had difficulty in identifying some sorts of errors*)

#### Box 2. Questions put to Scientists, research assistants, technicians (GROUP 2 – about 6 members)

Discuss and report back on

- (a) your views on *current strengths* and *weaknesses* within the banana programme with respect to data management
- (b) your recommendations for the future with respect to data management.

##### **Flip-Chart Presentation:**

##### *Strengths:*

- Well sensitised staff data management
- Trained data managers
- Machines/Computers
- Literature/Materials (software) (*This was with reference to June 2003 workshop materials and MS-office and statistics software*)
- Good interaction with data managers and statisticians
- Well developed protocols for data collection and entry sheets.

##### *Weaknesses:*

- Limited literature (*The group indicated that they would like more literature on data mgt to be available*)
- Short training courses (*Previous years workshop was too short to acquire full skills in data management*)
- Few data managers (*only 2 in NBRP and 1 in IITA – staff need more help in their work*)
- Data security (*concerns about wanting confidence that data will not be accessed unlawfully*)
- Computers (*limited computers for data management work*).

##### *Recommendations:*

- Continuous training
- Strengthening central data management
- Training materials
- Security (data)



### **Box 3. Questions put to Data Management Specialists – 3 members**

Discuss and report back on

- (a) changes (if any) you have observed in the past year of research staff's level of ability to prepare computerised clean data sets relating to their research work
- (b) changes (if any) in staff attitude towards research data management
- (c) the current level of recognition amongst scientists, research assistants and technicians, of the importance of data management in research.

#### ***Flip-Chart Presentation:***

- (a) Changes in researchers' skills
  - Files and folder's tree structures well organised
  - Proper data sets with descriptors
  - More consultations with data managers, especially on new activities.
- (b) Changes in staff attitude
  - Positive/security – presenter commented that the Data Managers also has a position to defend and that scientists data would be well safeguarded.
  - However, priorities vary among the research scientists.
- (c) Current level of awareness
  - Knowledge has flowed down to technicians who now consult more.
- (d) Weakness
  - Mix work/learning – Presenter commented that the Data Managers are also learning while helping others in data management – and sometimes found the work and learning components getting mixed – so they need to be careful.

### **Box 4. Questions put to Senior scientists and those responsible for research management – 3 members including Head, Banana Programme**

Discuss and report back on key points you would want to convey to new NBRP recruits (scientists, PhD/MSc students, research assistants, technicians, field assistants) about the programme's recommendations on best practice in data management and how you would help them to learn the process.

#### ***Flip-Chart Presentation:***

- Orientation of new staff recruited to the NBRP – to be a policy
- Periodic reviews on compliance of data management guidelines
- Refresher courses to update staff on new developments on data management
- Policy for senior scientists to nurture new recruits.



## Appendix 9 (Part B)

### Data managers' views of current the status of data management

The short questionnaire below was given to the data managers and statisticians to seek their additional individual opinions about any changes they have perceived amongst research staff since the workshop in June 2003 on Research Data Management. The questionnaire, together with their responses are summarised below. The four persons who answered the questionnaire were: Yusuf Mulumba (Statistician, NBRP), Allan Rwakitungu (Research Assistant, NBRP), Hussein Kisingo (IITA data manager) and Philip Ragama (IITA statistician). The varied responses reflect to some extent the fact that in general they would give advice to different persons.

#### =====

#### Data Management Specialists (please use reverse of sheet for any additional comments)

1. Amongst those who attended the "Research Data Management" training last year, what **changes** have you observed in the past year with respect to their skills in data management (e.g. level of organisation, checking of data, etc).

- *They have developed interest in data management; they have adding value to what they have learnt; they are teaching others (technicians).*
- *Those who attended the course last year consult with biometricians more so do a better job of data management.*
- *More reliable data with fewer mistakes, mostly by the data takers; setting up and validating rules which ensure good data; better file naming system and folders.*
- *Many participants are now more conscious on dealing with the common errors, with a view of correcting them easier, can now supervise data collection and entering much better.*

2. What weaknesses still remain amongst this group that needs improvement?

Score only elements where weaknesses still exists, on a 1-5 scale (1=extremely weak; 5=only slightly weak)

|  | 1                              | 2                              | 3                              | 4                              | 5                              |
|--|--------------------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
| Preparing data recording sheets or questionnaires    | <input type="text"/>           | <input type="text"/>           | <input type="text" value="3"/> | <input type="text"/>           | <input type="text" value="1"/> |
| Setting up computer screens for the data entry       | <input type="text"/>           | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text" value="1"/> |
| Seeking help from Biometrics at the appropriate time | <input type="text"/>           | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text"/>           | <input type="text" value="2"/> |
| Data checking/cleaning procedures                    | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text"/>           | <input type="text" value="1"/> | <input type="text"/>           |
| Keeping meta-data in the data file                   | <input type="text"/>           | <input type="text" value="1"/> | <input type="text"/>           | <input type="text" value="2"/> | <input type="text" value="1"/> |

Comments: THERE ARE SOME SCIENTISTS INVOLVED IN SURVEY WORK AND NOT ABLE TO SET UP SCREENS.

3. To what extent have you been able to influence those who have had no previous data management training, in improving their skills and attitude towards data management? (1=very little; 10=quite a lot)

|                    | 1                    | 2                    | 3                              | 4                    | 5                              | 6                              | 7                              | 8                              | 9                    | 10                   |
|--------------------|----------------------|----------------------|--------------------------------|----------------------|--------------------------------|--------------------------------|--------------------------------|--------------------------------|----------------------|----------------------|
| Improving skills   | <input type="text"/> | <input type="text"/> | <input type="text" value="1"/> | <input type="text"/> | <input type="text" value="1"/> | <input type="text"/>           | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text"/> | <input type="text"/> |
| Improving attitude | <input type="text"/> | <input type="text"/> | <input type="text"/>           | <input type="text"/> | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text" value="1"/> | <input type="text"/> | <input type="text"/> |

Comments: No comments were given.



4. What are your views about the data management skills of those that who did not attend the training? Score all entries below on a 1-6 scale (1=extremely weak; 5=only slightly weak; 6=adequate)

|  | 1 | 2 | 3 | 4 | 5 | 6 |
|--|---|---|---|---|---|---|
| Preparing data recording sheets or questionnaires    | 1 | 2 |   |   |   |   |
| Setting up computer screens for the data entry       | 2 |   | 1 |   |   |   |
| Seeking help from Biometrics at the appropriate time | 1 |   | 1 |   |   | 1 |
| Data checking/cleaning procedures                    | 1 | 2 |   |   |   |   |
| Keeping meta-data in the data file                   | 2 | 1 |   |   |   |   |

Comments:

- They acknowledge the importance of data management, but they can't do most of it themselves.
- Scientists may not follow good data management to the book but they are aware what they need to do.
- In fact some programs in Kwanda, like CIAT, too had wanted some technicians from their group to be trained in this kind of course. Probably we may need to try and train them on the job or organise a small workshop.



**National Agricultural Research Organisation, Uganda  
Kawanda Agricultural Research Institute, Kampala**



# **Uganda National Banana Research Programme**

## **Policy for Research Management**

**with particular emphasis on  
Research Data Management & Statistical Analysis**

May 2004



## Foreword

The policies described here for research management, with emphasis on data management and statistical analysis, have been developed by staff of the National Banana Research Programme (NBRP) in Uganda, in collaboration with the Statistical Services Centre of the University of Reading, U.K., to achieve a well-coordinated approach to the management of research activities, and in particular for managing research data arising from its numerous activities. The aim is to have a streamlined approach for researchers to follow throughout the research process so that high quality research outputs can be achieved on the basis of reliable data that can be trusted by other researchers and policy makers.

The development of these guidelines has been funded by the Crop Protection Programme (CPP) of DFID UK, a key donor of several research projects within NBRP. CPP recognised the need for the development of an effective database management system for research activities within NBRP and agreed in early 2003 to fund initial activities that would support NBRP in achieving this goal. The funding covered the archiving of all data, meta-data and study protocols of the CPP-funded cluster of banana projects, the setting up of guidelines and procedures necessary for maintaining a good database management system, and developing and documenting an appropriate data management strategy for all NBRP research activities. This document forms the last of these three outputs.

The development of this policy has been greatly assisted by NBRP's interaction with a range of external collaborators, and it draws on the wide experiences of NBRP staff's work since the inception of the programme. Although this document has been adopted by NBRP as its current policy, it will be reviewed from time to time as new experiences emerge.

< some comments from Director, KARI >

Dr. Mathias Magunda  
Director  
Kawanda Agricultural Research Institute, NARO



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## ***Acknowledgements:***

The National Banana Research Programme (NBRP), based at Kawanda Agricultural Research Institute, Uganda, gratefully acknowledges funding from the Crop Protection Programme of the UK Government's Department for International Development (DFID) in the development of the first version of this policy document but the views expressed here are not necessarily those of DFID. NBRP also acknowledges with thanks, the Statistical Services Centre at the University of Reading, U.K. for initiating and backstopping this work intensively over a 15-month period, and the National Agricultural Research Organisation (NARO) and the International Institute of Tropical Agriculture (IITA) for their support.



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## APPENDICES

Appendix 1. Template for the Project Protocol

Appendix 2. Template of a Research Activity Protocol

Appendix 3. Agreement with partners on access to data and authorship of papers

## ACRONYMS

NARO National Agricultural Research Organisation

NBRP National Banana Research Programme

DMG Data Management Guidelines

DRS Data Recording Sheet

DG Director General

FA Field Assistant



# 1. Policy Definitions

## 1.1 Project:

A body of work that has a clearly defined proposal, with a specific budget, with a named lead scientist and a named source of funds.

## 1.2 Sub-Project:

One specific component or research theme of the project with a named leader.

## 1.3 Research Activity:

An experiment, lab study, survey, focus group discussion, etc., with a clearly defined activity leader.

## 1.4 Project Team:

Those named in the project proposal and visibly contributing to the achievement of project outputs.

## 1.5 Project Leader:

The Lead Scientist in the National Banana Research Programme (NBRP), who is named in the project proposal. The Project Leader will

- (a) have final responsibility for delivering project outputs;
- (b) liaise with collaborators;
- (c) be responsible for maintaining a record of project progress in a project folder (see 1.8 below);
- (d) prepare and maintain an overall project protocol (see Appendix 1 for template);
- (e) ensure effective monitoring of all aspect of research activities;
- (f) be responsible for ensuring progress reports are maintained and provide a summary of these reports to the Head of the National Banana Research Programme (NBRP) at three monthly intervals;
- (g) be responsible for preparing an authority list (see 5.2 below) for data access.

## 1.6 The research activity or specific research discipline leader (Short title: Activity Leader):

Named scientist who will lead specific research activities and report progress to the Project Leader at regular intervals. If for example, the Activity Leader is a PhD student, the Project Leader could be the Head of the Banana Programme. More typically, the Activity Leader will be a scientist or MSc student or Research Assistant who undertakes the work at the request of the Project Leader.

The Activity Leader will take primary responsibility for the activity and will also be responsible for

- (a) maintaining an activity folder and the data status monitoring report (see *Guidelines and Procedures for Effective Data Management* (DMG) Manual);
- (b) providing the Project Leader with a three-monthly progress report for inclusion in the project working folder (see 1.8 below).

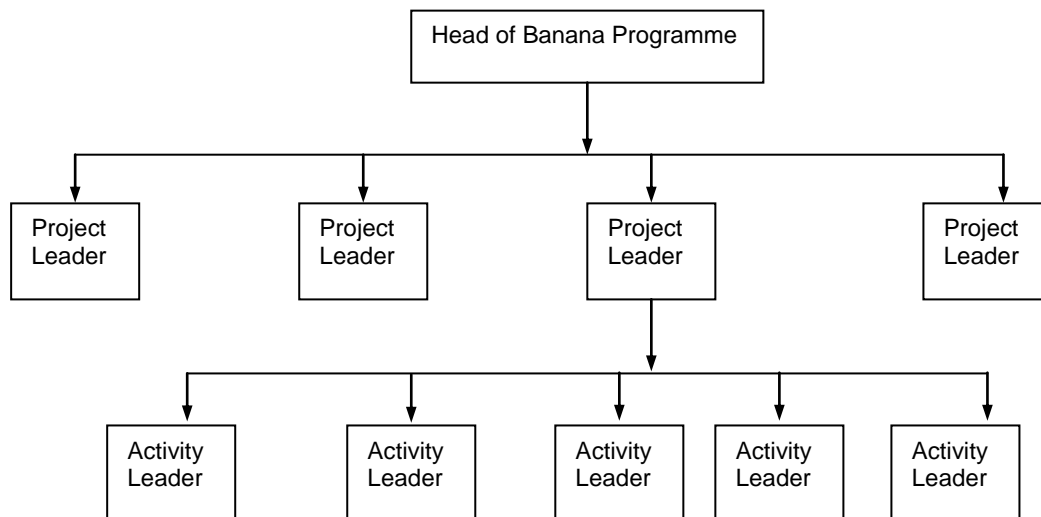
## 1.7 Management Structure:

A project will have only one leader who will be responsible to the Head of the NBRP. One person may be the leader of more than one project.

A Scientist, Research Assistant or Technician may be an Activity Leader for more than one research activity within one project or across several projects. Figure 1 shows the line of responsibility.



**Figure 1. NBRP lines of responsibility**



**1.8 The Project working folder:**

A file held by the Project Leader to document progress of project activities. This will include the project proposal, funding details, the overall integrative project protocol, protocols for each research activity, progress reports, etc.

**1.9 The Data Owner:**

NARO is the data owner of all the research data and will hold copyright to its policies, manuals and compilation of its information. NARO may use its discretion to share data with others as appropriate and consistent with contractual obligations to funders.

**1.10 The data custodian:**

The Data Manager in the Biometrics Unit will be the NBRP data custodian and receive all cleaned and computerised data files, together with the associated data sheets from project Activity Leaders. The data files will have full information needed to understand the meaning of the data. (See also sections 4.5 and 5).

**1.11 Management Monitoring Panel:**

A committee of at least 3 members with responsibility for ensuring compliance with NBRP policy and guidelines and procedures for effective data management.

## **2. Pre-funding Activities**

### **2.1 Problem identification and team formation**

2.1.1 Researchers and Stakeholders together will identify a researchable problem. This component may involve external collaborators if so required by the funding organisation. Those involved will need to establish this is an important problem, that the means exist to tackle it effectively, and that something worthwhile will be able to be done with the research results. They should also establish that on these criteria the proposed research is preferable to other possible approaches.

2.1.2 Concurrently with the above activity, a review of the literature will be undertaken, to clarify gaps in scientific knowledge and to determine how these link to the problem identified in 2.1.1.

2.1.3 Research team members for the project will be identified, together with a named lead scientist, i.e. person who will be the Project Leader. The Project Leader will be responsible for ensuring that the research proposal is submitted by specified deadlines to the funding body (or collaborator).



2.1.4 Clear objectives for the project will be documented and agreed by all key players.

## **2.2 Preparation of Project Proposal**

2.2.1 The Project Leader will prepare the project proposal in consultation with relevant team members and collaborators. Where this is done by an external collaborator, the Project Leader will liaise with that collaborator to ensure that the proposal satisfies NARO requirements and policies.

2.2.2 Scientists named in the proposal will have an appropriate percentage of their time explicitly specified in the work plan. At the same time, their availability for project activities during agreed (expected) times must be cross-checked with them.

2.2.3 Depending on the expected volume of data generated, a small percentage of the budget (typically 2% - 10%) must be allocated to the Biometrics Unit. This is to cover their contributions to project planning meetings and study design activities, assistance with setting up data collection forms, receiving data sets and keeping back-ups, and for their help in statistical analysis of the data and in the reporting of statistical results. Such activities should be checked with the Biometrics Unit to ensure that the budget allocation for data collection, computerisation, validation, management and analysis is realistic.

2.2.4 Dissemination pathways for research outputs must be identified in collaboration with relevant stakeholders. Anticipated costs (including 2% - 10% of budget allocation to the Communications Unit) must be included within the project workplan and checked with the Communications Unit to ensure that the budget is realistic.

2.2.5 A copy of the final proposal will be given, via the Head of the NBRP, to DG-NARO for approval and submission to the funding organisation.

## **3. Initial Activities following Funding Approval**

### **3.1 Administrative Issues**

3.1.1 The Project Leader will be responsible for ensuring contractual details are agreed with collaborating partners and that contracts are signed by NARO authority.

3.1.2 A copy of the approved project proposal will be lodged with DG-NARO, Head of NBRP and the Banana Finance Office.

3.1.3 The Project Leader will inform all key research team members of funding approval for the project and expected start dates.

### **3.2 Planning the overall study**

3.2.1 The Project Leader will call a Planning Meeting of all scientists contributing to the project and staff (statistician/data manager) of the Biometrics Unit.

3.2.2 This meeting will cover the following activities.

- i. Agreement on the sampling structure (site and farmer identification and how many; documenting justification for sampling procedure against project objectives).
- ii. Identifying specific research questions.
- iii. Identifying activities within each research question.
- iv. Identifying leaders for :
  - a. Data management activities, i.e. the Data Manager
  - b. Each research activity, i.e. the Activity Leader



- v. Defining roles and responsibilities of other key players, e.g. scientists, Field Assistants, technicians, biometrics unit members, data entry persons.
- vi. The Project Leader will prepare an activity time chart with deadlines clearly specified for completion of specific activities. This should be in accordance with scientists' current availability for each of the research activities.
- vii. He/she will also prepare a table detailing each activity by person(s) responsible for the activity, together with the anticipated number of days for each **calendar year** required by the person for the activity, as shown below. This chart will be a component of the project working folder (see 1.8).

| Title of Project    | Title of activity | Person 1 | Person 2 | Person 3 | etc | etc |
|---------------------|-------------------|----------|----------|----------|-----|-----|
| Project 1           | Activity 1.1      |          |          |          |     |     |
| Project 1           | Activity 1.2      |          |          |          |     |     |
| Project 1           | Activity 1.3      |          |          |          |     |     |
| etc                 | etc               |          |          |          |     |     |
| Project 1 sub-total |                   | 50 days  | 60 days  | 10 days  | etc | etc |
| Project 2           | Activity 2.1      |          |          |          |     |     |
| Project 2           | Activity 2.2      |          |          |          |     |     |
| Project 2           | Activity 2.3      |          |          |          |     |     |
| etc                 | etc               |          |          |          |     |     |
| Project 2 sub-total |                   | 20 days  | 5 days   | 26 days  | etc | etc |
| Project 3           | Activity 3.1      |          |          |          |     |     |
| etc                 | etc               |          |          |          |     |     |

3.2.3 In accordance with discussions at the Planning Meeting above, the Project Leader will:

- i. Prepare an overall project protocol (see Appendix 1 for template) and submit a hard copy to Head, NBRP and a soft copy to the Biometrics Unit. A soft copy of the project proposal (without financial details), and a soft copy of the Planning Meeting minutes, will also be submitted to the Biometrics Unit.
- ii. Submit an extract of the above to Biometrics Unit for inclusion in NBRP's website. This extract will include the project title, an abstract of the project (background, objectives, and current status), research partners involved and the donor (at a minimum). It will also name the NBRP Project Leader with a link to that person's e-mail address.
- iii. Feed the sub-total rows of the table under 3.2.2 (vii) to the Programme Leader to enable compilation of a chart of time allocation for NBRP staff across all projects, as shown below. The total number of workdays expected of a staff member will vary according to their position and other administrative duties.

| Title of project | Person 1  | Person 2  | Person 3  | etc | etc |
|------------------|-----------|-----------|-----------|-----|-----|
| Project 1        |           |           |           |     |     |
| Project 2        |           |           |           |     |     |
| Project 3        |           |           |           |     |     |
| etc              |           |           |           |     |     |
| Total            | <240 days | <240 days | <240 days | etc | etc |



## 4. Implementation of Research Activities

### 4.1 Policy for activity implementation

4.1.1 NBRP research staff will adhere as closely as possible to NBRP's policy as given below with respect to implementation of project activities. The information in the document entitled *Guidelines and Procedures for Effective Data Management* manual<sup>1</sup> serves to assist staff in this process. Relevant sections as appropriate for the research work must be read, understood<sup>2</sup>, and good practice in data management as recommended in the DMG manual followed throughout the research process.

4.1.2 Although the Activity Leader is mentioned below, he/she will work with other team members in implementing the work schedules below.

### 4.2 Planning the activity and data collection

#### 4.2.1 Study Design

- i. Activity leader will prepare a draft protocol for the activity (see Appendix 2 for a template).
- ii. Activity leader will discuss the study design details specified in the protocol with the biometrician and make revisions accordingly (this may involve a visit to the study site).
- iii. Designing on-farm trials is likely to present special challenges, and section 4.1.3 of the DMG manual must be consulted when planning such studies.
- iv. Copy of final protocol will be lodged with the Biometrics Unit and with the Project Leader.
- v. Any changes to the protocol specification during progress of the activity will result in an updated version, which will then replace previous copies lodged with the Biometrics Unit and with the Head of NBRP.

#### 4.2.2 Designing data collection instruments, setting up data sheets and pilot testing

- i. Activity Leader will design the data collection instrument, i.e. a data recording sheet (DRS) which may take the form of a recording schedule for farmer participatory work, or a data collection form for recording experimental records, or a survey questionnaire.
- ii. A document justifying the inclusion (in the DRS) of each measurement variable or question (in a questionnaire or checklist) in terms of its contribution to the research objectives, will be prepared by the Activity Leader and submitted to the Project Leader for inclusion in the Project Working Folder.
- iii. The DRS will be reviewed by the Biometrics Unit and any revisions agreed with the scientist.
- iv. Data entry sheets will be prepared by the scientist (inclusive of data validation checks) in consultation with the Biometrics Unit. (Where it is not the Biometrics Unit's responsibility to manage the data, the Unit will still play an advisory role).
- v. Final approval of data collection/data entry sheets will be given by the Biometrics Unit.
- vi. A Field Assistant (FA) will be identified in consultation with the site co-ordinator, and FA's time allocation for project activities and timeframe for field data collection (including pilot testing) agreed.
- vii. Training of FA in field data collection will take place concurrently with pilot testing of the DRS in the field (scientist, FA, technicians (if relevant), biometrician)
- viii. Data entry screens will be re-checked against the piloted data and revised accordingly.

#### 4.2.3 Setting up on-farm studies and on-station/lab experiments

- i. Procedures for the study will be set up and agreed. For studies involving farmers, timing of activities must be agreed in advance with the site-co-ordinator, the farmers and other personnel involved.
- ii. Consistent labelling, of the measurement units or farmer names across different activities, must be ensured.
- iii. If the farmer is expected to keep records, it will be important to ensure that (a) these are kept to the absolute minimum; (b) the farmer has been properly trained in record keeping (what, how, when and where); (c) the farmer understands why good records are important and how it would

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<sup>1</sup> The *Guidelines and Procedures for Effective Data Management* Manual will be referred to as the Data Management Guidelines, or DMG manual for short.

<sup>2</sup> Where the guidelines are not clear, the Project Leader or the Biometrics Unit should be consulted



- help him/her and other farmers in the longer term. Any constraints indicated by the farmer in maintaining good records will be noted.
- iv. The field plan at each site will be prepared on a spreadsheet and its filename included in the protocol.

#### 4.2.4 Data Collection

- i. For activities done by postgraduate students, the organisation and management of the DRS will be done by the student to enhance their own skills, but they will be supervised by the Project Leader.
- ii. For activities led by NBRP scientists, the organisation and management of the DRS will be done by a named data entry person and supervised by the Biometrics Unit staff. This will require some liaison between the field data collectors, the site-coordinator and the data entry personnel to ensure that the DRS forms are not misplaced between the field and the Biometrics office. The DRS forms will be kept in the Biometrics Office conditional upon space being available.
- iii. In the case of (ii) above, the data entry person will be responsible for liaising with the activity leader to ensure the DRS are stored and maintained as expected (see also 4.3.1 below).

### 4.3 Office editing and coding (where necessary)

4.3.1 There will be a manual review by the Activity Leader of each DRS for accuracy and consistency with respect to scientific expectations of the results. Any queries arising will be raised with the FA and/or site co-ordinator.

4.3.2 For survey work, coding of survey questionnaires and/or other recording sheets will be decided by the Activity Leader, who will then supervise the coding work done by the data entry person.

### 4.4 Data computerisation and verification

4.4.1 Data entry will be done as soon as possible after data collection for the activity has been completed to enable data queries to be checked with the data collectors.

4.4.2 Data entry will be done by a named technician or a named data entry person, and supervised by the Activity Leader, consulting with the Biometrics Unit as and when needed.

4.4.3 Data entry will be checked, either by double data entry by two different data entry persons, or by using manual checks against paper records. In the former case, comparing the two data files after their entry for any differences will be done by the Project Data Manager. In the latter case, the work will be done by the technician or data entry personnel and supervised by the Activity Leader.

4.4.4 Data files after first entry will be passed to the Project Data Manager (if there is one) or the Biometrics Unit. The data will also be copied to the Activity Leader if not already with him/her).

4.4.5 Further editing/cleaning of the computerised data will be done by the Activity Leader prior to any attempt at data analysis.

4.4.6 Presenting final **clean** data files, as and when they become available, to the Biometrics Unit for purposes of archiving, will be the responsibility of the Activity Leader.

### 4.5 Archiving the data, meta-data, reports and other materials

4.5.1 When field data collection and data computerisation is complete, the Activity Leader will be responsible for ensuring that the protocol is in its final form and that it includes the names of all data files generated through that activity. An electronic copy of this protocol will be passed to the Project Leader and to the Biometrics Unit for inclusion in the project archive.

4.5.2 It will be the responsibility of the Project Leader to ensure that all relevant information pertaining to the project have been included in the archive. The following information should be included within one month of the completion of project activities (including submission of final technical report).



- i. Project description. This could be extracted from the project proposal and should show the background justification for the research, the overall objectives, intended (achieved) outputs, an outline of activities and plans for dissemination.
- ii. Proceedings of Stakeholder Meetings, and Minutes of Planning Meetings
- iii. Raw data with a clear description of all the variables therein and labels for coded variables.
- iv. Detailed protocols for the project as a whole, as well as for each research activity. The latter will show links to the raw data file names.
- v. Other related materials (maps, photos, etc)
- vi. Programs used for data management
- vii. Programs used for statistical analysis
- viii. Progress reports submitted to the funding donor
- ix. Technical Reports.

4.5.3 Once the project archive is complete, a CD of the archive will be lodged with the Head of the Banana Programme. A copy will also be given to the Project Leader. A CD of the archive will be made available to others on request.

4.5.4 The Project Leader in consultation with the Head of the Banana Programme will decide at this time a time frame for inclusion of selected components of the archive on the banana website.

## 5. Backing-up Data Files and Data Security

5.1 The Biometrics Unit will be responsible for archiving all data, meta data, reports, protocols and other materials generated through project activities within NBRP.

5.2 The Project Leader, in consultation with the Head of the Banana Programme will be responsible for providing the Biometrics Unit with a list of names of those who have authority to access the data. The Unit will maintain a logbook to record (i) the date, (ii) name of recipient, (iii) the recipient's role in the project or reasons for accessing the data, and (iv) a signature from the recipient that he/she will not misuse guidelines set up for the data user. Where the recipient is not a member of the *authorised list* for data access, the Head of the Biometrics Unit will seek advice from the Project Leader or the Head of NBRP about allowing data access.

5.3 Operational procedures concerning data access will be in accordance with guidelines agreed between the Biometrics Unit and Head, NBRP.

5.4 The Biometrics Unit will not have the authority to use or divulge the data, or any associated information relating to the data to persons not named in the authorised list, without consultation with the researcher responsible for the activity. In the absence of the researcher, permission should be sought from the Head of NBRP.

5.5 The Biometrics Unit will be responsible for preparing a back-up of the full banana data archive, once every two weeks, e.g. every other Friday afternoon. If substantial changes to the archive are made before the set time for the back-up, an extra copy will be made soon after such substantial revisions are done. The back-up CD(s) will be kept in a locked cupboard in the Programme Leader's office. The first back-up CD for the month will be kept in the Programme Leader's home for safety against possible damage to the office block at Kawanda.

5.6 Project Leaders and Activity Leaders will regularly update the archive to keep it current.

5.7 Only one computer in the Biometrics Unit will include the archive in its most current form. Only the data managers in the Biometrics Unit will have access to this computer through password secured accounts. It will also not be available to other users through network share. It will not be used for e-mail access to minimise dangers from effects of computer viruses.

5.8 A second computer will be maintained in the Biometrics Unit for receiving data sets in the first instance. They will then be checked for completeness of the information before they are transferred to the main data archive. Once the transfer is made and the files are backed-up, they will be deleted from this second computer to ensure there is no unauthorised access.



## 6. Analysing the Data and Presentation of Statistical Results

6.1 Descriptive analyses of raw data will be carried out by the Activity Leader (refer to DMG Manual).

6.2 Data errors identified during the preliminary analyses will be corrected by the Activity Leader and the updated data files passed to the Biometrics Unit for inclusion in the data archive.

6.3 Activity Leader, together with the Project Leader, will consult the Biometrician to discuss analytical approach to meet research objectives.

6.4 Activity Leader, guided by the Biometrician, will undertake the data analysis. Complex analyses may be undertaken by the Biometrician, liaising with the Activity Leader.

6.5 The Biometrician will assist the scientist in interpreting statistical analysis results, and both will discuss the results to ensure that research objectives have been met.

6.6 Further analysis will be undertaken by the scientist or the Biometrician to answer any further research questions which may be appropriate.

6.7 Scientist will write up the results of the statistical analysis and cross-check it with the biometrician for appropriateness of approaches used for reporting and presenting the results of the statistical analyses, and accuracy of interpretation.

## 7. Reporting and Publications

7.1 Reports to the funding organisation will be submitted by the Project Leader by the required deadline.

7.2 If the project involves recommendations for the release of new improved technologies, the Release Document should be prepared by the Project Leader and submitted to the appropriate authority through the Head of NBRP.

7.3 As soon as possible after project completion, i.e. submission of the Final Technical Report, the Project Leader will organise a meeting of the scientists involved in the project in order to (a) discuss what components of the research could form the basis for scientific publications and (b) to draw up a time schedule for the completion of proposed publications. If external collaborators are involved, the Project Leader will also liaise with such persons during this process.

7.4 Procedures agreed with research partners on data access and authorship for papers, as given in Appendix 3, will be followed. Project collaborators will be requested to read and sign the document given in Appendix 3.

## 8. Dissemination of Research Outputs

8.1 In consultation with relevant Stakeholders, dissemination pathways for research outputs will be identified.

8.2 Procedures for promotional activities will be developed in consultation with the Development and Communications Unit at Kawanda. Consideration will be given to the following aspects.

- i. **What** is being disseminated?
- ii. **Who** are the beneficiaries?
- iii. **What** are the key messages?
- iv. In **what** format should the dissemination take place (e.g. what media?)
- v. **Who** will be responsible for these activities?
- vi. **When** will it be done?

8.3 The Project Leader will be responsible for documenting procedures for dissemination and assessing its impact on target beneficiaries.



## **9. Implementing best practices in Research and Data Management**

9.1 The Management Monitoring Panel will meet once in three months to monitor compliance with NBRP policy by Project Leaders and Activity Leaders.

9.2 Orientation of new NBRP staff to good practices in data management will be done by the Biometrics Unit.

9.3 Orientation of new NBRP staff to good practices in research management and research techniques will be done by NBRP senior scientists.

9.4 Refresher courses will be held at regular intervals to update staff on new developments in data management.

9.5 Forging of data has occasionally been encountered with hired field staff off-station. NBRP will regard the forging of data (e.g. filling questionnaires without visiting the household) as a criminal offence and will take serious action if evidence indicates that such misconduct has taken place. The failure on the part of the supervisor to detect in time and deal with extensive data fraud will be treated as professional negligence.



## APPENDIX 1

### Template for the Project Protocol<sup>3</sup>

**Project Title:** <The title as given in the project proposal>

**Project Leader:** <Lead scientist for the project as defined in section 1.5>

**Research Partners:** <Name and organisation of each partner>

**Project Funding:** <Donor(s) supporting the project>

**Start and end dates:** <Month and year as specified in the project proposal and interim milestones>

**Project Purpose:** <The overall goal in broad terms, specifying intended beneficiaries – direct and indirect>

**Project Justification:** <Brief outline of why the project is being undertaken>

**Specific Project Objectives:** <Objectives defined precisely>

**List of intended Outputs:** <Outputs as indicated in the project proposal>

**Research disciplines corresponding to project objectives:** <This may be helpful in identifying which subject area specialists are needed>

**Research questions with justification:** <For each research theme, clear explicit statements of the specific research questions to be answered (as decided at the Project Planning Meeting). See DMG Manual Appendix 1 for an example>

**List of research activities with named activity leaders:** <The link between these activities and the research questions should be clear>

**Conceptual Framework:** <This is intended to demonstrate how the research themes and/or research activities link with the objectives and outcomes. It will also show how the different research themes link to each other. This will serve to guide the way in which data is collected and analysed to address the overall project purpose>

**Procedure for sample selection (Sampling Protocol):** <e.g. method of selecting farmers for a baseline survey or for on-farm studies, method of selecting specific areas in institute's field for on-station studies, soil sampling, etc., addressing sample size issues and demonstrating how sampling activities link together>

**Procedure for implementing each study activity:** <When, who, how(in broad terms) and expected date of completion. This could be in the form of a table with rows listing the activities and columns representing the when, who, how and completion date. See Appendix 1 of DMG manual for an example>

**Data management strategy (an outline extracted from the Data Management Protocol):** <Identifying persons and procedures for data collection, data entry and validation, data organisation, archiving, backing-up of files, keeping recording sheets in a safe place, etc.>

**List of documents relating to the Project:** <This will be updated over the duration of the project and will include planning meeting minutes, workshop reports, progress reports, short technical documents, etc. These will help in checking items for inclusion in the project archive.>

**Plans for dissemination:** <A brief outline of what is intended, extracted from the project proposal>

**List of publications, conference papers, and other technical articles:** <This list will be updated as the project progresses>

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<sup>3</sup> Above list is not claimed or intended to be definitive. For an example, see Appendix 1 of the DMG manual.



## APPENDIX 2

### Template of a Research Activity Protocol<sup>4</sup>

**Activity Title:** <A title for the activity>

**Project Title:** <A title for the project to which the activity contributes>

**Project Leader:** <Lead scientist for the project as defined in section 1.5>

**Activity Leader:** <Name of scientist, research assistant or technician responsible for the activity>

**Other members contributing to the activity:** <Names of technician(s), FA, Data Entry personnel, etc.>

**Project Funding:** <Donor(s) supporting the project>

**Research Partners:** <Names of external organisations and/or collaborators>

**Start and end dates:** <Month and year as specified in the project proposal>

**Background:** <Background to the activity and how it relates to the overall project objectives>

**Objectives:** <Clearly specified objective(s) for the activity>

**Materials and Methods:**

- i. *Location(s):* Where is the activity being carried out?
- ii. *Important dates associated with the sub-project or activity:* Start and end dates, planting dates (for field studies), dates for field staff training, pilot testing, data collection, etc.
- iii. *Study design details:* Survey or experimental methodology in detail addressing the what, where, when, who, how components. See DMG Manual Appendices 2-6 for examples from different types of studies. The sampling procedure should be detailed.
- iv. *Materials to be used:* Where from, how processed (if relevant), data collection instruments.

**What data is to be collected and when and why:** <Specify broad types of data to be collected (e.g. socio-economic, labour use, climate data, disease assessments, etc), how they relate to overall project objectives, and specific measurements to be made within each data type and when>

**Data Status:** <A record (to be updated as the research activity progresses) of the status of data collection, computerisation, cleaning and availability in the archive for each of the data types above>

**Data analysis plan:** <Identification of the specific objectives of the analysis, listing variables to be used, noting steps needed to organise the data into the right format for analysis, and an indication of the type of approach to be undertaken during the data analysis and the software to be used>

**Activity related computer files:** <A list of all the data and other files generated through the research activity. This list will be updated as the activity progresses. The naming format given in the DMG manual section 7.1.2 should be followed>

**List of farmers:** <(If on-farm study) or any other list relevant to the sampling units for the study>

**Protocol filename:** <The name used for the electronic copy of the protocol, following the naming format given in the DMG manual section 7.1.2.

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<sup>4</sup> Above list is not claimed or intended to be definitive. For examples, see Appendices 2 to 6 of the DMG manual.



## **APPENDIX 3**

### **THE NATIONAL BANANA RESEARCH PROGRAMME (NBRP) NATIONAL AGRICULTURAL RESEARCH ORGANISATION (NARO)**

#### **Agreement with partners on access to data and authorship of papers for refereed publications, articles and conferences**

##### **Accessing data.**

All scientists collaborating on an activity/experiment will have access to the data. Persons not directly involved in the research may have access to the data only with written permission from the Head of the National Banana Research Programme (or his/her equivalent in case of title change). After two years following successful delivery of the final technical report to the funding agency, requests for access will not normally be denied without good reason. All data users will be required to cite the National Banana Research Programme as the source of the data in their presentations/publications.

##### **Publications/data use**

The lead scientist for each activity should be given the first opportunity to draft papers from the respective data and to be the first author. NARO policy requires that a collaborator who initiates a publication should include a NARO scientist as a co-author.

To merit getting your name on a paper, 3 out of the 5 criteria below should be substantially met:

- i. Securing funds, e.g. writing the project application/designing the work programme/being the grant holder.
- ii. Conception and Design, e.g. Planning the experiment/work; making an intellectual contribution towards the design and/or execution of the work.
- iii. Implementation and/or contribution towards implementation, including data management or data cleaning.
- iv. Analysing the data.
- v. Writing up, e.g. initial drafting and/or making substantial contributions to improving the text.

##### **Publication development process**

The first draft of any paper for publication should be submitted to the Head of the NBRP as soon as it is ready. This should include a list of authors and a justification showing their contributions according to items (i) to (v) above.

NBRP will appoint a panel consisting of at least three senior scientists who will review the authorship line up in accordance with contributions made during the research process, or to be made in paper writing.

Special cases, which deviate from the publication criteria and development process will be considered by the panel on a case-by-case basis.

##### **Acknowledgement.**

All publications should acknowledge the donor who funded the research and the partners who contributed but are not part of the authorship line up.

##### **Acceptance of above terms by NBRP scientists and collaborators:**

I have read and agree to the conditions above. I further agree that data or other related information I receive will not be divulged to a third party without prior permission from Head, NBRP.

Name:

Designation:

Signature:

Date:



## **Project Protocol for IPM Project R7567/ ZA0372**

**Project Title:** Integrated management of banana diseases in Uganda

**Project Leaders:** Dr. Mike Rutherford (CABI Bioscience, UK) and Dr. Simon Gowen (University of Reading, UK)

**Overseas research partners:**

Dr. W. Tushemereirwe, Head, Uganda National Banana Research Programme (UNBRP), Kampala, Uganda

Dr. Cliff Gold, International Institute of Tropical Agriculture (IITA), Kampala, Uganda

**Other UK research partners:**

Dr. Savitri Abeyasekera, University of Reading

Dr. Richard Lamboll, Natural Resources Institute (NRI)

**Project Funding:** DFID Crop Protection Programme

**Start and end dates:** January 2000 – June 2003

**Project Purpose:** Promotion of strategies to reduce the impact of pests in herbaceous crops in Forest Agriculture systems, for the benefit of poor people.

**Project Justification:**

Banana is the most important single crop for food and income security in Uganda. Yet over the last 44 years there has been a steady but marked decline in production of bananas in Uganda. While the area of land under bananas (c. 1.5 million hectares) is double that of 1956, banana production in traditional producing areas of central and eastern Uganda has severely declined. The decline in these areas has been reflected by a shift in production from central regions in particular, such as Luwero, to western Uganda. But even in these, relatively productive, regions, there has been a gradual decline with yields currently at only 17 tons/ha/year respectively (compared with 60 tons/ha/year attainable on research stations).

Baseline research conducted by the UNBRP throughout the banana growing areas identified and prioritized a number key constraints to production, including declining soil fertility, a complex of pests and diseases, post harvest problems, socioeconomic constraints and low genetic diversity. This project was aimed at addressing pest and disease problems by using an integrated pest management approach.

**Specific Project Objective:**

To evaluate and validate, under farmer conditions, improved banana crop and resource management technologies suitable for particular agro-ecological zones and farming systems.

**List of intended Outputs:**

- Series of well co-ordinated and managed trials designed, established and maintained across benchmark sites to address priority issues, including improvements in banana health, with full stakeholder liaison and farmer participation and producing valid conclusions
- Protocols for determining plant growth vigour, health, pest and disease populations established for field use
- Cultivars with different yield /growth characteristics evaluated for disease and nematode resistance under farmer field conditions
- Cultural conditions which improve plant vigour, health and productivity are evaluated and defined under farmer conditions
- Suitable practices accepted by farmers for ongoing validation for sustainable improvement of banana productivity.



- Etiology of wilt-like disorder resolved and options for control by farmers formulated for on-farm trials
- Farmer, extension service and NARS scientific staff recognition and awareness of banana pest and disease constraints and the beneficial effects of cultural farming practices enhanced through participation in on-farm trials

### Project Logframe:

| Narrative Summary   | Objectively Verifiable Indicators   | Means of Verification   | Important Assumptions  |
|---|---|---|--|
| <b>Goal</b>   |   |   |  |
| Benefits for poor people generated by application of new knowledge on crop protection to annual and herbaceous crops in Forest Agriculture production systems.  | To be completed by Programme Manager  | To be completed by Programme Manager  | To be completed by Programme Manager   |
| <b>Purpose</b>  |   |   |  |
| Promotion of strategies to reduce the impact of pests in herbaceous crops in Forest Agriculture systems, for the benefit of poor people.  | To be completed by Programme Manager  | To be completed by Programme Manager  | To be completed by Programme Manager   |
| <b>Outputs</b>  |   |   |  |
| <ol style="list-style-type: none"> <li>1. A series of well co-ordinated and managed trials designed, established and maintained across benchmark sites to address priority issues, including improvements in banana health, with full stakeholder liaison and farmer participation and producing valid conclusions.</li> <li>2. Protocols for determining plant growth vigour, health, pest and beneficial populations are established for field use.</li> <li>3. Varieties with different yield /growth characteristics evaluated for disease and nematode resistance under farmer field conditions.</li> <li>4. Cultural conditions which improve plant vigour, health and productivity evaluated and defined under farmer conditions</li> <li>5. Suitable practices accepted by farmers for ongoing validation for sustainable improvement of banana productivity.</li> <li>6. Etiology of matoke wilt resolved and options for control by farmers formulated for on-farm trials.</li> <li>7. Farmer, extension service and NARS scientific staff recognition and awareness of banana pest and disease constraints and the beneficial effects of cultural farming practices enhanced through participation in</li> </ol> | <p>Inputs made to benchmark site activities as agreed, trials completed on schedule and to satisfaction of all stakeholders. Technologies for improving crop health validated.</p> <p>Protocols being routinely applied as part of technology evaluation process.</p> <p>On-farm varietal evaluation completed. Relative resistance of different banana varieties determined.</p> <p>On-farm evaluation of cultural farming conditions completed. Relative effects on plant health, vigour and productivity determined.</p> <p>Pathways for wider validation of selected practices by UNBRP identified.</p> <p>Potentially beneficial management options for matoke wilt identified and available for further uptake as part of evaluation process.</p> <p>More accurate and comprehensive information being received from farmers, extension services and NARS</p> | <ul style="list-style-type: none"> <li>• NARES reports</li> <li>• Project quarterly, annual and final technical reports</li> <li>• Publications in national, regional and international bulletins, reports and journals</li> <li>• Presentation at scientific meetings</li> </ul> | Socio-political situation remains favourable for the work to be undertaken, for banana production and marketing and for adoption of project outputs. |



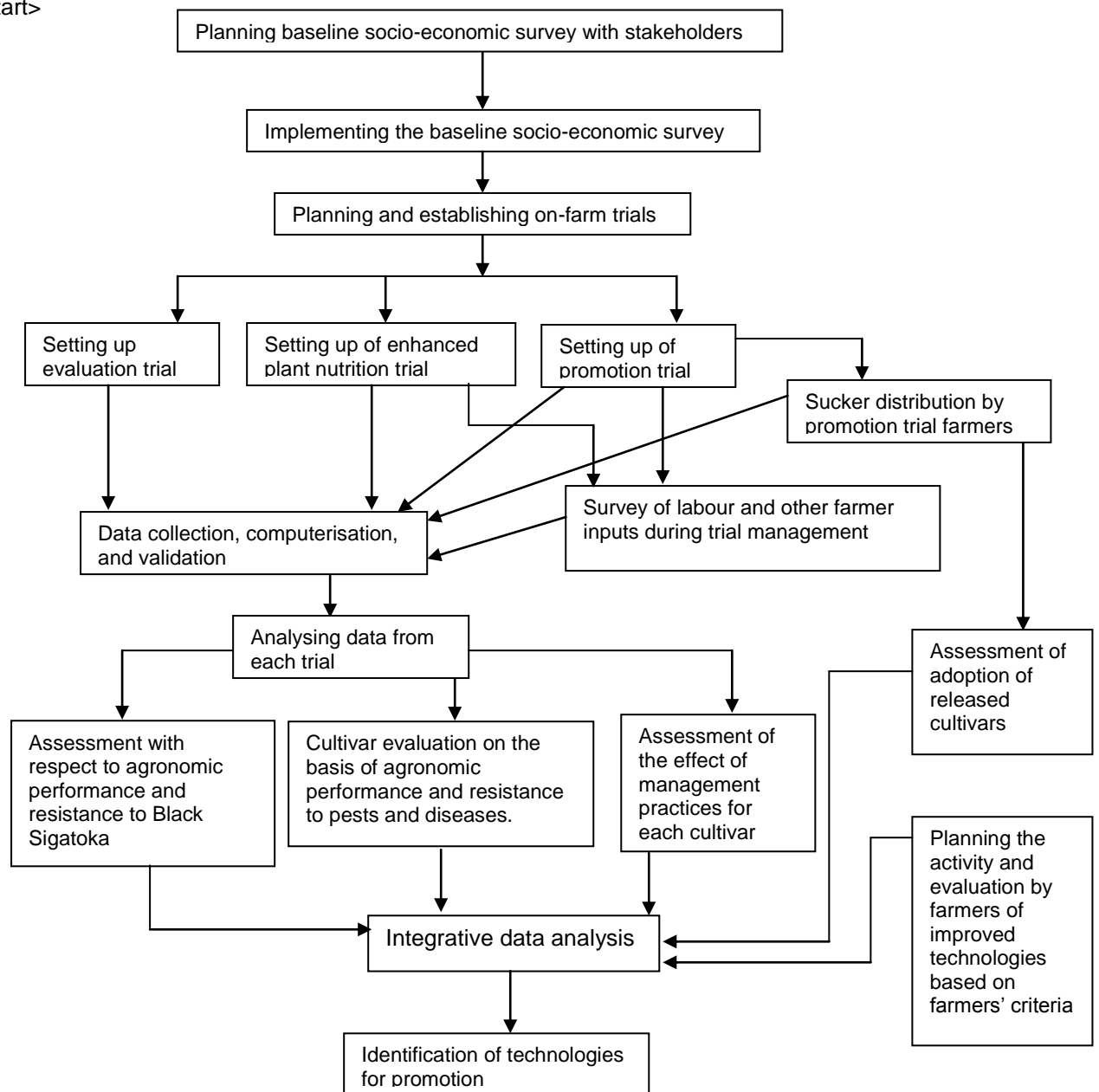
| on-farm trials.   | scientific staff. |                       |  |
|---|-------------------|-----------------------|--|
| Activities  | Inputs            | Means of Verification | Important Assumptions  |
| 1.1-7.1 Initial planning meeting to assist UNBRP in determining criteria for trials to improve banana health at benchmark sites. Selection of cultivars for field evaluation and cultural practices which show potential for increasing plant health and vigour (year 1).   |                   | •                     |  |
| 1.2-7.2 Design benchmark site trials to evaluate the effects of cultural farm management practices and resistant germplasm on major diseases and nematode pests under on-farm conditions, (NARO/CABI/UR/IITA/NRI, year 1).  |                   | • As above            | That cultural management technologies and suitable germplasm to be evaluated are made available for the benchmark trials.                          |
| 1.3-7.3 Co-ordination and scientific management of all benchmark site trials in conjunction with inputs from IITA, including those involving DfID CPP-funded components (NARO/IITA, years 1-4).   |                   |                       | That field sites suitable for farmer participatory trials and other activities are available.  |
| 1.4-5.4, 7.4 Determine avenues by which nematode tolerant Indian material evaluated under R6391 can be introduced and evaluated under Uganda farm conditions (year 1).  |                   |                       | That farmers, extension services, local scientists, and other stakeholders agree to participate and that required inputs are utilised effectively. |
| 1.5-7.5 Select protocols for sampling, evaluating and quantifying disease severity and damage, plant vigour, root health, pathogen and nematode populations and other organisms from the trials (year 1).   |                   |                       |  |
| 1.6-7.6 Assist UNBRP to monitor effects on these of potentially beneficial management practices and different cultivars in field trails. Determine influence of factors on plantation longevity (years 1-4).  |                   |                       |  |
| 1.7-7.7 Determine which practices and cultivars can be used to improve health of bananas and ensure longevity of mats. Establish longer term protocols for validation in on-farm trails with farmer groups.   |                   |                       |  |
| 1.8, 2.8, 6.8, 7.8 Investigate factors relating to the development of matoke wilt on indigenous highland bananas, including possible causal agents, nutritional effects, interactions with other pests and agronomic factors. Identify practices that show potential for limiting or preventing wilt development (years 1-4). |                   |                       |  |
| 1.9-7.9 Farmer/extension service training workshops to monitor progress, determine relative effectiveness of technologies and acceptability to farmers, disseminate research outputs and plan and facilitate further uptake of results through local farmer/stakeholder initiatives (years 2-4).                              |                   |                       |  |

Note: Outputs should be numbered 1, 2, 3, *etc.* Activities should relate to these outputs and be numbered 1.1, 1.2, ...2.1, 2.2, ....*etc*



## LINKS BETWEEN RESEARCH ACTIVITIES:

<start>

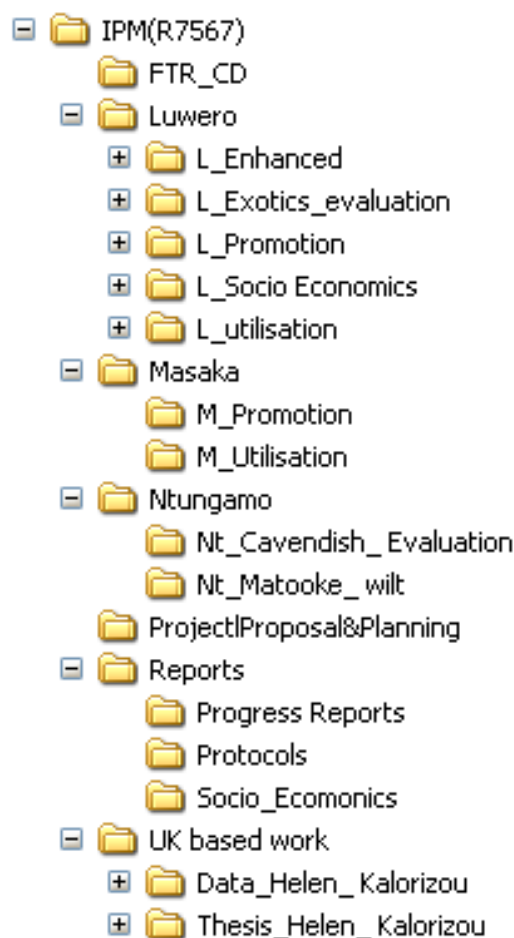


<end of data related activities>



## Structure of the archive for project data and associated meta-data

(a) Overall directory structure in the archive:



(b) Data files within each of the above folders:

*b1. IPM(R7567)\FTR\_CD* This contains all the contents of the Project's Final Technical Report.

| Name ▲                   | Size      | Type                    | Modified         |
|--------------------------|-----------|-------------------------|------------------|
| R7567 FTR .DOC           | 310 KB    | Microsoft Word Docum... | 18/11/2003 09:34 |
| R7567 FTR APPENDICES.DOC | 642 KB    | Microsoft Word Docum... | 18/11/2003 09:34 |
| R7567 FTR FIGURES.DOC    | 756 KB    | Microsoft Word Docum... | 18/11/2003 09:34 |
| R7567 FTR PLATES.DOC     | 25,716 KB | Microsoft Word Docum... | 18/11/2003 09:34 |
| R7567 FTR TABLES.DOC     | 464 KB    | Microsoft Word Docum... | 18/11/2003 09:34 |



*b2. IPM(R7567)\Luwero\Enhanced\*

| Name ▲                               | Size     | Type                   | Date Modified    |
|--------------------------------------|----------|------------------------|------------------|
| L_EN_Analysis                        |          | File Folder            | 18/05/2004 09:32 |
| L_EN_Protocol_AK1.doc                | 88 KB    | Microsoft Word Doc...  | 11/04/2004 14:49 |
| L_EN_beneficiary names corrected.xls | 17 KB    | Microsoft Excel Wor... | 26/08/2003 08:02 |
| L_EN_Growth_Nov03.xls                | 231 KB   | Microsoft Excel Wor... | 19/04/2004 13:14 |
| L_EN_Nematodes_Nov03.xls             | 1,548 KB | Microsoft Excel Wor... | 19/04/2004 14:50 |
| L_EN_Weevils_Nov03.xls               | 50 KB    | Microsoft Excel Wor... | 19/04/2004 13:44 |

*b3 IPM(R7567)\Luwero\Exotic\_evaluation*

| Name ▲                       | Size   | Type                   | Date Modified    |
|------------------------------|--------|------------------------|------------------|
| L_EV_ANALYSIS                |        | File Folder            | 18/05/2004 09:32 |
| L_EV_Protocol_AK2.doc        | 48 KB  | Microsoft Word Doc...  | 11/04/2004 16:42 |
| L_EV_Growth_cycle1_Jul03.xls | 345 KB | Microsoft Excel Wor... | 19/04/2004 13:54 |
| L_EV_NEMATODES_YR_02.xls     | 59 KB  | Microsoft Excel Wor... | 19/04/2004 14:01 |
| L_EV_Plot&Plant_Nos.doc      | 53 KB  | Microsoft Word Doc...  | 29/02/2004 06:29 |

*b4 IPM(R7567)\Luwero\Promotion*

| Name ▲                               | Size     | Type                   | Date Modified    |
|--------------------------------------|----------|------------------------|------------------|
| L_PR_Analysis                        |          | File Folder            | 18/05/2004 09:32 |
| L_PR_nematodes_YR_02 Nov03.xls       | 580 KB   | Microsoft Excel Wor... | 19/04/2004 14:41 |
| L_PR_nematodes_YR_03 Nov03.xls       | 1,163 KB | Microsoft Excel Wor... | 19/04/2004 14:41 |
| L_PR_weevils_YR_02 Nov03.xls         | 96 KB    | Microsoft Excel Wor... | 19/04/2004 14:41 |
| L_PR_weevils_YR_03 Nov03.xls         | 232 KB   | Microsoft Excel Wor... | 19/04/2004 14:41 |
| L_PR_beneficiary names corrected.xls | 24 KB    | Microsoft Excel Wor... | 26/08/2003 08:03 |
| L_PR_Growth_Cycle1 Nov03.xls         | 202 KB   | Microsoft Excel Wor... | 19/04/2004 14:41 |
| L_PR_Growth_Cycle2_Nov03.xls         | 269 KB   | Microsoft Excel Wor... | 19/04/2004 14:05 |
| L_PR_Plot&Plant_Nos.doc              | 155 KB   | Microsoft Word Doc...  | 29/02/2004 06:27 |
| L_PR_Protocol_AK3.doc                | 99 KB    | Microsoft Word Doc...  | 11/04/2004 17:25 |

*b5. IPM(R7567)\Luwero\Socio Economics*

| Name ▲                                 | Size     | Type                   | Date Modified    |
|--|----------|------------------------|------------------|
| L_SocioEcon_Analysis                   |          | File Folder            | 18/05/2004 09:32 |
| Beneficiary names.xls                  | 18 KB    | Microsoft Excel Wor... | 23/06/2003 12:57 |
| L_EN_Socio_Econ_Master_2003.xls        | 200 KB   | Microsoft Excel Wor... | 19/08/2003 09:45 |
| L_EN_Socio_Econ_Master_upto2002.xls    | 364 KB   | Microsoft Excel Wor... | 18/05/2004 06:14 |
| L_EV_Socio_Econ_Aug03.xls              | 193 KB   | Microsoft Excel Wor... | 19/08/2003 10:01 |
| L_PR_Socio_Econ_Master_2003.xls        | 289 KB   | Microsoft Excel Wor... | 19/08/2003 09:52 |
| L_PR_Socio_Econ_Master_upto2002.xls    | 2,485 KB | Microsoft Excel Wor... | 18/05/2004 06:26 |
| L_Socio_Econ_AllTrials_Master_2003.xls | 719 KB   | Microsoft Excel Wor... | 19/08/2003 09:30 |



*b6. IPM(R7567)\Luwero\LuUtilisation*

| Name ▲                                 | Size     | Type                   | Date Modified    |
|--|----------|------------------------|------------------|
| L_Util_Analysis                        |          | File Folder            | 18/05/2004 09:32 |
| crisps02.xls                           | 51 KB    | Microsoft Excel Wor... | 13/01/2004 07:38 |
| dataset3BOILEDfinalfilepromo.xls       | 67 KB    | Microsoft Excel Wor... | 16/01/2004 07:00 |
| dataset3EvaluationBoiledfinalfile.xls  | 64 KB    | Microsoft Excel Wor... | 16/01/2004 07:00 |
| dataset3EvaluationSteamedfinalfile.xls | 64 KB    | Microsoft Excel Wor... | 16/01/2004 07:00 |
| dataset3STEAMEDfinalfiles promo.xls    | 66 KB    | Microsoft Excel Wor... | 16/01/2004 07:00 |
| IPM_PostHarvestEvaluationDataFiles.doc | 42 KB    | Microsoft Word Doc...  | 14/04/2004 12:53 |
| L_EV_Ut_Crisps_Mar03.xls               | 2,508 KB | Microsoft Excel Wor... | 13/01/2004 07:38 |
| L_EV_Ut_Katongo_Mar03.xls              | 29 KB    | Microsoft Excel Wor... | 13/01/2004 07:54 |
| L_EV_Ut_Steamed_Mar03.xls              | 767 KB   | Microsoft Excel Wor... | 19/03/2003 15:09 |
| L_EV_utilization_Master_Mar03.xls      | 169 KB   | Microsoft Excel Wor... | 26/08/2003 10:31 |
| L_PR&EV_util_muwumbo&katongo_Mar03.xls | 34 KB    | Microsoft Excel Wor... | 26/08/2003 08:55 |
| L_PR_Util_Crisps_Mar03.xls             | 5,021 KB | Microsoft Excel Wor... | 13/01/2004 07:54 |
| L_PR_Util_Steamed_Mar03.xls            | 55 KB    | Microsoft Excel Wor... | 13/01/2004 07:54 |

*b7. IPM(R7567)\MasakaM\_Promotion*

| Name ▲                          | Size   | Type                   | Date Modified    |
|---------------------------------|--------|------------------------|------------------|
| M_PR_Kabana 38&485Promotion.xls | 134 KB | Microsoft Excel Wor... | 01/03/2004 07:16 |
| M_PR_anal1.sas                  | 4 KB   | SAS System Program     | 02/07/2003 07:27 |
| M_PR_anal1output.sas            | 10 KB  | SAS System Program     | 02/07/2003 07:02 |
| M_PR_Protocol_AK4.doc           | 53 KB  | Microsoft Word Doc...  | 11/04/2004 12:05 |

*b8. IPM(R7567)\MasakaM\_Utilisation*

| Name ▲                                 | Size  | Type                      | Modified         |
|--|-------|---------------------------|------------------|
| M_EV_APRIL02_KISSEKA_anlysis_jun03.sav | 8 KB  | SPSS Data Document        | 03/06/2003 16:17 |
| M_EV_APRIL02_KISSEKA_April03.xls       | 50 KB | Microsoft Excel Worksh... | 30/05/2003 10:20 |
| M_EV_Lugolobi_KISSEKA_April03.xls      | 20 KB | Microsoft Excel Worksh... | 30/05/2003 10:09 |
| M_utilisation_april02_Syntax1.SPS      | 1 KB  | SPSS Syntax Document      | 03/06/2003 16:34 |

*b9. IPM(R7567)\WtungamoWt\_Matooke\_wilt*




| Name ▲                             | Size   | Type                   | Date Modified    |
|------------------------------------|--------|------------------------|------------------|
| Nt_Matooke_Analysis.xls            | 56 KB  | Microsoft Excel Wor... | 19/04/2004 12:21 |
| Nt_Matooke_Output.doc              | 45 KB  | Microsoft Word Doc...  | 19/08/2003 14:55 |
| Nt_Protocol_Matooke_wilt_AK5.doc   | 31 KB  | Microsoft Word Doc...  | 11/04/2004 12:37 |
| Ntungamo_IPM_Matookewilt_mar03.xls | 295 KB | Microsoft Excel Wor... | 19/04/2004 12:19 |

*b10. IPM(R7567)\WtungamoWt\_Cavendish\_Evaluation*








| Name ▲                                  | Size   | Type                   | Date Modified    |
|---|--------|------------------------|------------------|
| NM_Cavendish_EV_cycle1_Mar03.xls        | 320 KB | Microsoft Excel Wor... | 19/08/2003 17:23 |
| Nt_Protocol_CavendishEvaluation_AK6.doc | 24 KB  | Microsoft Word Doc...  | 11/04/2004 14:08 |










*b11. IPM(R7567)\ProjectProposals&Planning*

| Name ▲   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
|  Methodology Discussions, KARI.doc    | 30 KB  | Microsoft Word Doc... | 15/04/2004 06:32 |
|  Planning meet rpt July 2000.doc      | 270 KB | Microsoft Word Doc... | 15/04/2004 06:32 |
|  ZA0372_R7567ProjectProposalToCPP.doc | 164 KB | Microsoft Word Doc... | 15/04/2004 06:32 |






*b12. IPM(R7567)\Reports\Progress Reports*

| Name ▲  | Size   | Type                  | Date Modified    |
|---|--------|-----------------------|------------------|
|  BiometricsVisitRecomm's_Jul02.doc       | 38 KB  | Microsoft Word Doc... | 03/01/2003 14:35 |
|  BiometricsVisitReport_SavitriJune01.doc | 131 KB | Microsoft Word Doc... | 15/11/2003 07:01 |
|  BiometricVisitReport_SavitriJuly02.doc  | 79 KB  | Microsoft Word Doc... | 19/08/2002 15:12 |
|  ClusterMtgMinutes_Jan02.doc             | 48 KB  | Microsoft Word Doc... | 09/07/2002 14:02 |
|  ProgressLuweroJul00-May01.doc           | 472 KB | Microsoft Word Doc... | 03/03/2003 11:24 |
|  SocioEconVisitReport_Lamboll2002.doc    | 143 KB | Microsoft Word Doc... | 11/02/2003 15:23 |
|  SocioEconVisitReport_LambollJun01.doc   | 127 KB | Microsoft Word Doc... | 20/09/2001 14:43 |

*b13. IPM(R7567)\Reports\Protocols*




| Name ▲   | Size  | Type                    | Modified         |
|--|-------|-------------------------|------------------|
|  L_EN_Protocol_AK1.doc                                  | 88 KB | Microsoft Word Docum... | 11/04/2004 16:49 |
|  L_EV_Protocol_AK2.doc                                  | 48 KB | Microsoft Word Docum... | 11/04/2004 18:42 |
|  L_PR_Protocol_AK3.doc                                  | 99 KB | Microsoft Word Docum... | 11/04/2004 19:25 |
|  M_PR_Protocol_AK4.doc                                  | 53 KB | Microsoft Word Docum... | 11/04/2004 14:05 |
|  Nt_Protocol_CavendishEvaluation_AK6.doc                | 24 KB | Microsoft Word Docum... | 11/04/2004 16:08 |
|  Nt_Protocol_Matooke_wilt_AK5.doc                       | 31 KB | Microsoft Word Docum... | 11/04/2004 14:37 |
|  Protocol for weevil and nematode damage assessment.doc | 23 KB | Microsoft Word Docum... | 18/11/2003 09:34 |

*b14. IPM(R7567)\Reports\Socio\_Economics*








| Name ▲   | Size   | Type                    | Modified         |
|--|--------|-------------------------|------------------|
|  LuweroBaselineQues'tre.doc   | 370 KB | Microsoft Word Docum... | 27/02/2003 06:38 |
|  LuweroBaselineReport2000.doc | 442 KB | Microsoft Word Docum... | 27/02/2003 06:31 |
|  Perf&ProfitBanana1999.doc    | 97 KB  | Microsoft Word Docum... | 27/02/2003 06:54 |
|  PRA.doc                      | 45 KB  | Microsoft Word Docum... | 27/02/2003 06:32 |
|  Understanding banana IPM.doc | 354 KB | Microsoft Word Docum... | 15/11/2003 05:43 |











*b15. IPM(R7567)\ProjectProposal&Planning*

| Name ▲   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
|  Methodology Discussions, KARI.doc    | 30 KB  | Microsoft Word Doc... | 15/04/2004 06:32 |
|  Planning meet rpt July 2000.doc      | 270 KB | Microsoft Word Doc... | 15/04/2004 06:32 |
|  ZA0372_R7567ProjectProposalToCPP.doc | 164 KB | Microsoft Word Doc... | 15/04/2004 06:32 |






*b16. IPM(R7567)\Reports/Progress Reports*

| Name ▲  | Size   | Type                  | Date Modified    |
|---|--------|-----------------------|------------------|
|  BiometricsVisitRecomm's_Jul02.doc       | 38 KB  | Microsoft Word Doc... | 03/01/2003 14:35 |
|  BiometricsVisitReport_SavitriJune01.doc | 131 KB | Microsoft Word Doc... | 15/11/2003 07:01 |
|  BiometricVisitReport_SavitriJuly02.doc  | 79 KB  | Microsoft Word Doc... | 19/08/2002 15:12 |
|  ClusterMtgMinutes_Jan02.doc             | 48 KB  | Microsoft Word Doc... | 09/07/2002 14:02 |
|  ProgressLuweroJul00-May01.doc           | 472 KB | Microsoft Word Doc... | 03/03/2003 11:24 |
|  SocioEconVisitReport_Lamboll2002.doc    | 143 KB | Microsoft Word Doc... | 11/02/2003 15:23 |
|  SocioEconVisitReport_LambollJun01.doc   | 127 KB | Microsoft Word Doc... | 20/09/2001 14:43 |

*b17. IPM(R7567)\Reports/Protocols*

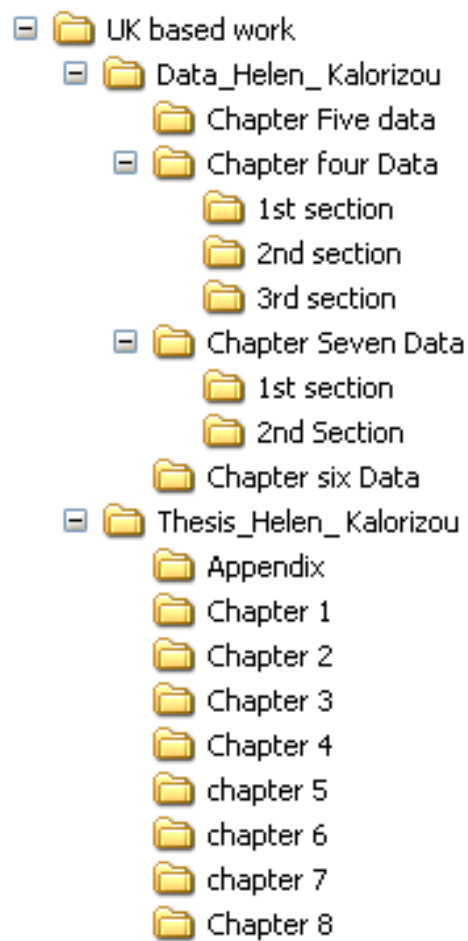
| Name ▲   | Size  | Type                  | Date Modified    |
|--|-------|-----------------------|------------------|
|  L_EN_Protocol_AK1.doc                                   | 88 KB | Microsoft Word Doc... | 11/04/2004 14:49 |
|  L_EV_Protocol_AK2.doc                                  | 48 KB | Microsoft Word Doc... | 11/04/2004 16:42 |
|  L_PR_Protocol_AK3.doc                                  | 99 KB | Microsoft Word Doc... | 11/04/2004 17:25 |
|  M_PR_Protocol_AK4.doc                                  | 53 KB | Microsoft Word Doc... | 11/04/2004 12:05 |
|  Nt_Protocol_CavendishEvaluation_AK6.doc                | 24 KB | Microsoft Word Doc... | 11/04/2004 14:08 |
|  Nt_Protocol_Matooke_wilt_AK5.doc                       | 31 KB | Microsoft Word Doc... | 11/04/2004 12:37 |
|  Protocol for weevil and nematode damage assessment.doc | 23 KB | Microsoft Word Doc... | 18/11/2003 10:34 |
|  Protocol_Cavendish_Mar03.doc                           | 26 KB | Microsoft Word Doc... | 24/03/2003 09:43 |

*b18. IPM(R7567)\Reports/Socio-Economics*

| Name ▲   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
|  LuweroBaselineQues're.doc    | 370 KB | Microsoft Word Doc... | 27/02/2003 07:38 |
|  LuweroBaselineReport2000.doc | 442 KB | Microsoft Word Doc... | 27/02/2003 07:31 |
|  Perf&ProfitBanana1999.doc    | 97 KB  | Microsoft Word Doc... | 27/02/2003 07:54 |
|  PRA.doc                      | 45 KB  | Microsoft Word Doc... | 27/02/2003 07:32 |
|  Understanding banana IPM.doc | 354 KB | Microsoft Word Doc... | 15/11/2003 06:43 |



b19. IPM(R7567)\UK\_based work (Individual data filenames are not shown but are contained in the sub-directories corresponding to the relevant chapters as shown below.





## Project Protocol for BSV Project R7529/ZA0365

**Project Title:** Epidemiology, vector studies and control of *Banana streak virus* in East African highland bananas

**Project Leader:** Dr. Lawrence Kenyon, Natural Resources Institute, U.K.

**Project Manager(s):** Charles Murekezi (Ph.D. student, University of Reading, U.K.) and Jerome Kubiriba (Ph.D. student, University of Greenwich), under the direction of Dr. W. Tushemereirwe, Head, Banana Research Programme, Uganda. Also Professor Dezi Ngambeki (Socio-economist, UNBRP).

**Research Partners:**

Dr. Tim Wheeler/Dr. Simon Gowen, University of Reading,  
Dr. Richard Lamboll and Timothy Chancellor, Natural Resources Institute, U.K.  
James Legg (and NRI), Jackie Hughes, Philip Ragama and Suluman Okech, International Institute of Tropical Agriculture.

**Project Funding:** DFID Crop-Protection Programme

**Start and end dates:** February 2000 – March 2003

**Project Purpose:** The purpose of this project was to gain a better understanding of the epidemiology and ecology of *Banana streak virus* (BSV) disease, and its importance and effect on banana production in Uganda.

**Project Justification:** The rationale behind this project was that, if the interaction between BSV spread and symptom expression and crop-growing conditions could be better understood, then low-cost/sustainable technologies that would moderate symptom expression or reduce the rate of spread, and hence reduce the losses caused, might be identified. While a lot of resources were being spent on detailed molecular studies (at JIC and at the University of Minnesota), there was a dearth of information on the epidemiology of the disease, its effect on yield under different management regimes and its interaction with stresses and other pests and diseases.

**Specific Project Objectives:** To explore the role of insect vectors in the spread of the virus in the field, and to identify putative vector species. By focusing on the Ugandan banana benchmark sites, some of the factors influencing BSV symptom expression were to be determined and yield loss under different conditions quantified. Using this information, cropping practices that could limit the spread of BSV and reduce the effect of the virus on productivity were to be identified.

**List of Outputs:**

**Output 1: BSV epidemiology and vectors**

*A clear understanding of whether BSV spreads naturally under field conditions in Uganda and, if it does, an indication of which vector species is/are the most effective at transmitting the disease.*

**Output 2: Stress and BSV activation and expression.**

*A better understanding of the role of different stresses on the activation of the virus and its symptom expression.*

**Outputs 3 & 4: Management Effects on BSV, Physiology and Growth.**

*Empirical data on the effect of (climate on) the disease, whether good management can alleviate the effects of the disease and restore yield to near normal and, based on these findings, formulation of a strategy for controlling, or at least managing, BSV in Uganda. The effects of BSV on the growth and yield of bananas quantified.*

**Output 5 & 6: Benchmark sites and Socio-economic aspects**

*Benchmark sites maintained and managed, and producing valid/reliable results from on-farm trials. Base-line data on the socio-economic aspects and consequences of BSV and of the project.*



## Output 7: Strengthening Capacity

*Strengthening of the Ugandan national programme's capacity for plant virus epidemiology/vector research and disease management.*

### Project Logframe (final version):

| Narrative Summary  | Objectively Verifiable Indicators  | Means of Verification   | Important Assumptions   |
|--|--|---|---|
| <b>Goal</b>  |  |   |   |
| Benefits for poor people generated by application of new knowledge on crop protection to annual and herbaceous crops in the Forest Agriculture production system.  | To be completed by Programme Manager   | To be completed by Programme Manager  | To be completed by Programme Manager  |
| <b>Purpose</b>   |  |   |   |
| Yields improved and sustainability enhanced in high potential cropping systems by cost-effective reduction in losses due to pests.   | To be completed by Programme Manager   | To be completed by Programme Manager  | To be completed by Programme Manager  |
| <b>Outputs</b>   |  |   |   |
| 1. A clear understanding of whether BSV spreads naturally under field conditions in Uganda and, if it does, an indication of which vector species is/are the most effective at transmitting the disease.   | Records of Cavendish "Williams" trials available. Colonies of identified vectors established and transmission trial data available | Project annual and final reports. Refereed journal publications.                    | Political and climatic conditions remain stable. Virus diagnostics remain available. Tissue culture facilities running smoothly. Field sites remain secure and laboratory facilities functional. Appropriate vehicle available. |
| 2. A better understanding of the role of different stresses on the activation of the virus and its symptom expression.   | Records of stress trials available and analysed.   | Project annual and final reports. Refereed journal publications.                    | as above  |
| 3. Empirical data on the effect of climate on the disease, whether good management can alleviate the effects of the disease and restore yield to near normal and, based on these findings, formulation of a strategy for controlling, or at least managing, BSV in Uganda. | Data from environmental and management field studies available. Strategies for managing BSV in Uganda determined.                  | Project annual and final reports. Refereed journal publications. Information sheet. | as above  |
| 4. The effects of BSV on the growth and yield of bananas quantified.   | Data from growth and yield study trials available and analysed.  | Project annual and final reports. Refereed journal publications.                    | as above  |
| 5. Benchmark sites maintained and managed, and producing valid/reliable results from on-farm trials  | Trials on benchmark sites successfully managed and completed.  | NARO Annual Reports.  | Appropriate bench mark site co-ordinators found and available. Local staff remain committed to, and available, for work..   |
| 6. Base-line data on the socio-economic aspects and consequences of BSV and of the project.  | Completed initial socio-economic study. Socio-economic impact assessment.  | Study report. Project final report.   | as above  |
| 7. Strengthening of the Ugandan national programme's capacity for plant virus epidemiology/vector research and disease management.   | Two NARO staff attached to project and trained in plant virus epidemiology /vector research and disease management.                | Project and NARO reports.   |   |
| <b>Activities</b>  | <b>Inputs</b>  | <b>Means of Verification</b>  | <b>Important Assumptions</b>  |
| 1.1 Field experiments at benchmark sites where BSV occurs to monitor the natural spread of BSV in blocks of 'trap plants' of virus-indexed Cavendish 'Williams' (NRI/NARO/IITA)  | Total Budget here  | 1.1 Records of Cavendish 'Williams' virus spread trials.                            | Political and climatic conditions remain stable.  |
| 1.2 Establish small plots of healthy bananas existing management trial and record symptom expression and yield in infected plants(NARO/NRI).   |  | 1.2 Records of banana management field trials.                                      | Virus diagnostics remain available, and detect most Uganda strains of BSV.  |
| 1.3. Collect, identify and culture potential insect vectors (Pseudococcidae) of BSV in   |  | 1.3 Colonies of identified vectors established                                      | Tissue culture facilities running smoothly.   |
|  |  |   | Field sites remain secure and laboratory facilities functional.   |

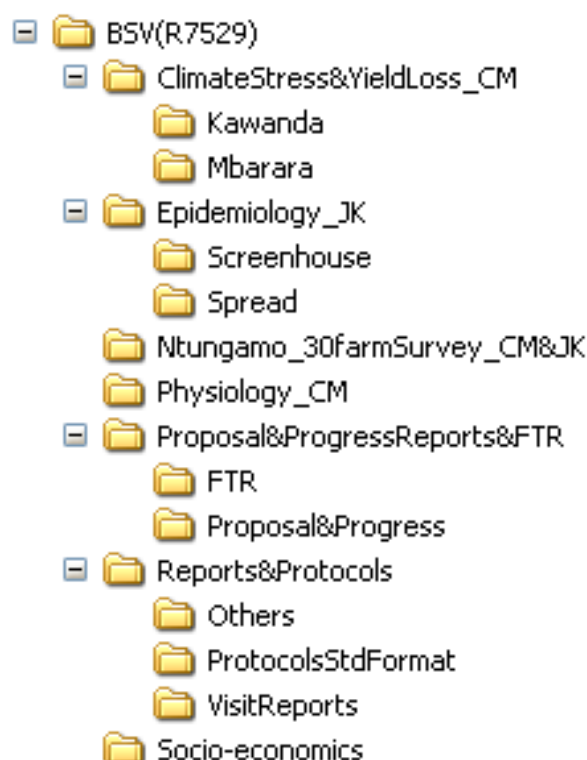


|   |   |   |  |
|---|---|---|--|
| Uganda (NRI/NARO/IITA)  |   |   | Appropriate vehicle available on time  |
| 1.4. Conduct BSV transmission tests to virus-tested Cavendish "Williams" with various locally-found mealybug species. (NRI/NARO/IITA)   |   | 1.4 Transmission trial data   |  |
| 2 Field trials to assess the effects of tissue culture propagation and hot water treatment, on the incidence and severity of BSV. (NARO/NRI/IITA/UoR)   |   | 2. Records and analysis of stress trials.   | as above   |
| <p>3.1 Trials at three contrasting sites to assess the effect of minimal and optimum management practices on BSV incidence and severity, and on crop productivity. (NARO/NRI/IITA/UoR)</p> <p>3.2 Experiments to elucidate the interactions between BSV, climate and management on crop productivity using modern physiological techniques to quantify resource use by the crops. (NRI/NARO/IITA/UoR)</p> <p>3.3 Formulate strategy for controlling the disease, and seek to identify promotional uptake pathways for the research findings. Produce information sheet. (NRI/NARO/IITA)</p> | <p>Total Budget here</p> <p>Staff Costs      £196,883</p> <p>Overheads      £ 79,970</p> <p>Capital</p> <p>Equipment      £ 18,852</p> <p>T&amp;S o/s      £ 46,182</p> <p>UK      £ 0</p> <p>Misc.      £ 86,350</p> <p>VAT      £ 0</p> <p><b>TOTAL      £428,237</b></p> | <p>3.1 Records of management trial</p> <p>3.2 Experiment results</p> <p>3.3 Information sheet .</p>   | <p>as above</p> <p>3.3 Tested practices do provide some control.</p>   |
| 4.1 Field trial to determine the effects of disease incidence and severity on the growth, development and yield of local landraces and improved banana varieties. (UoR/NRI/NARO/IITA)   |   | 4. Analysed data from growth and yield study trial.   | As above   |
| 4.2 Catalogue symptom development in plants in farmers fields at benchmark site and relate to final yield. (NRI/NARO)   |   | 4.2 Analysed data from farmers fields   | Benchmark site farmers are co-operative and record yields sufficiently accurately  |
| <p>5.1 Overall co-ordination and scientific management of benchmark sites in conjunction with Banana ICM project (CABI),. (NARO)</p> <p>5.2. Liaison with farmer groups and maintaining communication between research/extension and farmers, for on-farm trials at benchmark sites (NARO).</p> <p>5.3 Assist sister project (CN519) in collection of banana samples with symptoms for virus molecular variability studies. (NARO,NRI)</p>  |   | <p>Benchmark sites maintained and producing trial results</p> <p>farmers at benchmark sites actively involved in trials process</p> <p>Sister project has a range of material with different symptoms</p> | <p>Appropriate bench mark site co-ordinators found and available. Local staff remain committed to, and available, for work. as above</p> |
| <p>6.1 Socio-economic assessment of the factors associated with diseases and pests of the banana crop in Uganda, and of the proposed experiments to investigate them (Socio-economist and Biometrician).</p> <p>6.2 Socio-economic and biometric assessment at the end of the project of the research results/outputs. (Socio-economist &amp; Biometrician)</p>   |   | <p>Initial socio-economic study completed.</p> <p>Socio-economic impact of project assessed.</p>  | As above   |
| 7 Training and guidance to NARO, staff through active participation in epidemiology, virus diagnostics, physiology and vector activities.   |   | Two NARO staff employed by the project, trained in plant virus epidemiology /vector research and disease management.  | Identified NARO staff are receptive to the training offered  |



## Structure of the archive for project data and associated meta-data:

(a) Overall directory structure in the archive:



(b) Data files within each of the above folders:

*b1. BSV(R7529)\ClimateStree&YieldLoss\_CM\Kawanda*

| Name ▲                        | Size   | Type                   | Date Modified    |
|-------------------------------|--------|------------------------|------------------|
| K_CISt_BulkDen_1stYear.xls    | 23 KB  | Microsoft Excel Wor... | 18/11/2003 10:34 |
| K_CISt_BulkDen_baseline.xls   | 256 KB | Microsoft Excel Wor... | 19/01/2004 10:08 |
| K_CISt_Gr&Yld_climate00.xls   | 55 KB  | Microsoft Excel Wor... | 21/01/2004 08:27 |
| K_CISt_Gr&Yld_climate01.xls   | 54 KB  | Microsoft Excel Wor... | 21/01/2004 08:27 |
| K_CISt_Gr&Yld_climate02.xls   | 52 KB  | Microsoft Excel Wor... | 21/01/2004 08:29 |
| K_CISt_Gr&Yld_parent.xls      | 447 KB | Microsoft Excel Wor... | 21/01/2004 08:37 |
| K_CISt_PlantNut_1stRatoon.xls | 15 KB  | Microsoft Excel Wor... | 18/11/2003 10:34 |
| K_CISt_PlantNut_parent.xls    | 17 KB  | Microsoft Excel Wor... | 18/11/2003 10:34 |
| K_CISt_SoilNut_1stYear.xls    | 20 KB  | Microsoft Excel Wor... | 21/01/2004 08:36 |
| K_CISt_SoilNut_baseline.xls   | 18 KB  | Microsoft Excel Wor... | 21/01/2004 08:33 |
| K_CIStr_Gr&Yld_1st ratoon.xls | 513 KB | Microsoft Excel Wor... | 21/01/2004 08:24 |
| K_dataloggers.xls             | 20 KB  | Microsoft Excel Wor... | 19/01/2004 12:02 |



*b2. BSV(R7529)\ClimateStree&YieldLoss\_CMWbarara*

| Name ▲                        | Size   | Type                   | Date Modified    |
|-------------------------------|--------|------------------------|------------------|
| M_C&St_BulkDen_1stYear.xls    | 29 KB  | Microsoft Excel Wor... | 22/01/2004 09:13 |
| M_C&St_PlantNut_1stRatoon.xls | 25 KB  | Microsoft Excel Wor... | 22/01/2004 08:53 |
| M_C&St_SoilNut_1stYear.xls    | 20 KB  | Microsoft Excel Wor... | 22/01/2004 09:04 |
| M_C&St_SoilNut_baseline.xls   | 18 KB  | Microsoft Excel Wor... | 22/01/2004 06:57 |
| M_Clst_Gr&Yld_1stRatoon.xls   | 285 KB | Microsoft Excel Wor... | 22/01/2004 05:38 |
| M_Clst_Gr&Yld_climate02.xls   | 55 KB  | Microsoft Excel Wor... | 22/01/2004 12:42 |
| M_Clst_Gr&Yld_climate03.xls   | 47 KB  | Microsoft Excel Wor... | 22/01/2004 10:37 |
| M_Clst_Gr&Yld_dataloggers.xls | 26 KB  | Microsoft Excel Wor... | 22/01/2004 10:32 |
| M_Clst_Gr&Yld_parent.xls      | 193 KB | Microsoft Excel Wor... | 22/01/2004 05:40 |

*b3. BSV(R7529)\Epidemiology\_JK\Screenhouse*

| Name ▲           | Size   | Type                   | Date Modified    |
|------------------|--------|------------------------|------------------|
| K_Screen_BSV.xls | 806 KB | Microsoft Excel Wor... | 18/05/2004 06:53 |

*B4. BSV(R7529)\Epidemiology\_JK\Spread*

| Name ▲                    | Size     | Type                   | Date Modified    |
|---------------------------|----------|------------------------|------------------|
| K_Environ_Interaction.xls | 199 KB   | Microsoft Excel Wor... | 14/04/2004 07:55 |
| K_SPREAD_BSV.xls          | 16 KB    | Microsoft Excel Wor... | 10/02/2004 08:10 |
| K_spread_MEALY.xls        | 508 KB   | Microsoft Excel Wor... | 10/02/2004 08:11 |
| Mb_spread_MEALY.xls       | 419 KB   | Microsoft Excel Wor... | 10/02/2004 09:08 |
| Nt_spread_AAA-EA.xls      | 1,444 KB | Microsoft Excel Wor... | 18/05/2004 06:35 |
| Nt_spread_Small.xls       | 499 KB   | Microsoft Excel Wor... | 12/02/2004 09:46 |
| R_spread_AAA-EA.xls       | 4,039 KB | Microsoft Excel Wor... | 14/04/2004 07:39 |
| R_spread_Small.xls        | 795 KB   | Microsoft Excel Wor... | 26/08/2003 13:57 |

*B5. BSV(R7529)\Ntungamo\_30farmSurvey\_CM&JK*

|                        |          |                        |                  |
|------------------------|----------|------------------------|------------------|
| Nt_CulMgt_Gr&Yld.xls   | 2,843 KB | Microsoft Excel Wor... | 22/01/2004 11:56 |
| Nt_CulMgt_NutrSoil.xls | 21 KB    | Microsoft Excel Wor... | 22/01/2004 12:28 |
| Nt_MEALY.xls           | 2,164 KB | Microsoft Excel Wor... | 10/02/2004 07:25 |

*B6. BSV(R7529)\Physiology*

| Name ▲                          | Size   | Type                   | Date Modified    |
|---------------------------------|--------|------------------------|------------------|
| K&Mb_Phys_Photosynthesis_01.xls | 77 KB  | Microsoft Excel Wor... | 18/05/2004 07:24 |
| K_Biomass&LgtInterception.xls   | 42 KB  | Microsoft Excel Wor... | 18/05/2004 07:18 |
| K_Phys_BulkDen_1stYear.xls      | 25 KB  | Microsoft Excel Wor... | 22/01/2004 11:16 |
| K_Phys_BulkDen_baseline.xls     | 22 KB  | Microsoft Excel Wor... | 22/01/2004 11:14 |
| K_Phys_Gr&Yld_1stRatoon.xls     | 113 KB | Microsoft Excel Wor... | 22/01/2004 11:11 |
| K_Phys_Gr&Yld_parent.xls        | 253 KB | Microsoft Excel Wor... | 22/01/2004 14:11 |
| K_Phys_SoilNut_1stYear.xls      | 19 KB  | Microsoft Excel Wor... | 22/01/2004 11:13 |
| K_Phys_SoilNut_baseline.xls     | 18 KB  | Microsoft Excel Wor... | 22/01/2004 11:12 |



*B7. BSV(R7529)\Proposal&ProgressReports&FTR\FTR*

| Name ▲                        | Size     | Type                  | Date Modified    |
|-------------------------------|----------|-----------------------|------------------|
| An1_Epidemiology.doc          | 2,261 KB | Microsoft Word Doc... | 21/08/2003 14:15 |
| An2_mealybugs.doc             | 253 KB   | Microsoft Word Doc... | 21/08/2003 14:15 |
| An3_physiology_management.doc | 2,278 KB | Microsoft Word Doc... | 21/08/2003 14:15 |
| An4_Ntungamoreport.doc        | 1,739 KB | Microsoft Word Doc... | 21/08/2003 14:15 |
| An5_focusgroup.doc            | 251 KB   | Microsoft Word Doc... | 21/08/2003 14:15 |
| An6_baselinesurvey.doc        | 245 KB   | Microsoft Word Doc... | 21/08/2003 14:15 |
| An7_diagnostics.doc           | 4,572 KB | Microsoft Word Doc... | 21/08/2003 14:15 |
| ZA0365_FTR.DOC                | 210 KB   | Microsoft Word Doc... | 21/08/2003 14:15 |

*B8. BSV(R7529)\Proposal&ProgressReports&FTR\Proposal&Progress*

| Name ▲                    | Size     | Type                  | Date Modified    |
|---------------------------|----------|-----------------------|------------------|
| Quar_Report29sept2002.doc | 1,336 KB | Microsoft Word Doc... | 18/11/2003 10:34 |
| R7529 proposal.pdf        | 104 KB   | Adobe Acrobat Doc...  | 22/04/2004 14:29 |
| ZA0365 Q3 Jan01.pdf       | 11 KB    | Adobe Acrobat Doc...  | 22/04/2004 14:29 |
| ZA0365 AR 00-01a.pdf      | 10 KB    | Adobe Acrobat Doc...  | 22/04/2004 14:29 |
| ZA0365 AR 01-02.pdf       | 9 KB     | Adobe Acrobat Doc...  | 22/04/2004 14:29 |
| ZA0365 AR 99-00.pdf       | 9 KB     | Adobe Acrobat Doc...  | 22/04/2004 14:29 |
| ZA0365 ppr Jan 02.pdf     | 21 KB    | Adobe Acrobat Doc...  | 22/04/2004 12:08 |
| ZA0365 ppr Jan 03.pdf     | 23 KB    | Adobe Acrobat Doc...  | 22/04/2004 14:29 |
| ZA0365 ppr Sept 01.pdf    | 19 KB    | Adobe Acrobat Doc...  | 22/04/2004 12:08 |
| ZA0365 ppr Sept 02.pdf    | 22 KB    | Adobe Acrobat Doc...  | 22/04/2004 12:08 |
| ZA0365 Q1 Jun 00.pdf      | 10 KB    | Adobe Acrobat Doc...  | 22/04/2004 12:08 |
| ZA0365 Q2 Sept 00.pdf     | 11 KB    | Adobe Acrobat Doc...  | 22/04/2004 14:29 |

*B9. BSV(R7529)\Reports&Protocols\Others*


| Name ▲                             | Size     | Type                  | Date Modified    |
|------------------------------------|----------|-----------------------|------------------|
| CM_PhD_Proposal.doc                | 192 KB   | Microsoft Word Doc... | 18/11/2003 10:34 |
| CM_upgrade2.doc                    | 2,716 KB | Microsoft Word Doc... | 18/11/2003 10:34 |
| MEALYBUG IDENTIFICATION SHEET1.doc | 44 KB    | Microsoft Word Doc... | 01/03/2004 11:14 |

*B10. BSV(R7529)\Reports&Protocols\ProtocolsStdFormat*





| Name ▲                                   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
| Protocol_CLST_YldLoss_CM1.doc            | 67 KB  | Microsoft Word Doc... | 24/02/2004 10:46 |
| Protocol_Environment_Interaction_JK3.doc | 144 KB | Microsoft Word Doc... | 18/05/2004 06:54 |
| Protocol_NtungamoSurvey_CM&JK.doc        | 56 KB  | Microsoft Word Doc... | 24/02/2004 10:52 |
| Protocol_Phys_CM2.doc                    | 48 KB  | Microsoft Word Doc... | 24/02/2004 10:47 |
| Protocol_Screenhouse_JK2.doc             | 134 KB | Microsoft Word Doc... | 04/03/2004 08:02 |
| Protocol_Spread_JK1.doc                  | 144 KB | Microsoft Word Doc... | 02/03/2004 01:16 |



B11. BSV(R7529)\Reports&Protocols\VisitReports

| Name ▲   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
|  BiometricsVisitReportNov02.doc | 159 KB | Microsoft Word Doc... | 18/11/2003 09:34 |

B11. BSV(R7529)\SocioEconomics

| Name ▲  | Size   | Type                   | Date Modified    |
|---|--------|------------------------|------------------|
|  BSV_Baseline_survey_questionnaire_Mar03.doc | 71 KB  | Microsoft Word Doc...  | 24/03/2003 06:51 |
|  BSV_Survey Comments_from Savitri.doc        | 26 KB  | Microsoft Word Doc...  | 21/03/2004 06:55 |
|  bsv_survey_codes_Mar03.doc                  | 38 KB  | Microsoft Word Doc...  | 24/03/2003 06:52 |
|  L_M_NT_Survey_data_Mar03.XLS                | 312 KB | Microsoft Excel Wor... | 27/09/2003 08:01 |

**Project publications/outputs:**

- CHANCELLOR, T.C.B. (2000): Managing Banana Streak Virus. *CABI-Biocontrol News and Information* 21(3) September 2000 (<http://pest.cabweb.org/Journals/BNI/Bni21-3/IPM.htm>)
- JOOMUN, N. (2002): Development of Diagnostic Techniques for reliable detection of *Banana streak virus*. MSc Thesis Natural Resources Institute, University of Greenwich, Chatham pp. 73.
- KENYON, L., KUBIRIBA, J., MUREKEZI, C., RAGAMA, P., WHEELER, T., CHANCELLOR, T.C.B., TUSHEMERIRWE, W. and GOWEN, S (2003): *Banana streak virus* disease in Uganda. Poster No 1449 (Abstract 23.34) presented at the 8th International Congress of Plant Pathology (ICPP2003), Christchurch, New Zealand 2-7 February 2003.
- KUBIRIBA, J. TUSHEMERIRWE, W. and KENYON, L. (2003): Epidemiology of *Banana streak virus* (BSV) in East African Highland Bananas (Annex 1 of FTR)
- KUBIRIBA, J., JOOMUN, N. and KENYON, L. (2003): Detection of BSV in Ugandan bananas (Annex 7 of FTR)
- MUREKEZI, C. and KUBIRIBA, J. (2003): Effect of farmers' cultural practices on banana streak virus (BSV) expression in Ntungamo (Annex 4 of FTR)
- NGAMBEKI, D., KUBIRIBA, J., MUREKEZI, C., and RAGAMA, P., (2002): Baseline survey report: Banana streak virus on East African Highland bananas in south and western Uganda (Annex 6 of FTR)
- NGAMBEKI, D., KUBIRIBA, J., MUREKEZI, c., RAGAMA, P. and LAMBOLL, R. (2002): Farmer knowledge and perceptions of Banana streak virus on East African highland bananas in villages with relatively high BSV incidence in south-western Uganda (Annex 5 of FTR)
- WATSON, G. and KUBIRIBA, J. (Submitted): Identification of Mealybugs on Bananas and Plantain in Africa. *African Entomology*. (Annex 2 of FTR)
- WHEELER, T., MUREKEZI, C., GOWEN, S., KEBREAB, E. and TUSHEMERIRWE, W. (2003): Impact of *Banana streak virus* on the growth and yield of banana var. Cavendish Williams (Musa AAA) and var. Mbuzirume (Musa AAA-EA) (Annex 3 of FTR)



## **Project Protocol for Weevils Project R7972/ ZA0372**

**Project Title:** Integrated management of the banana weevil in Uganda

**Project Leaders:** Dr. Simon Gowen (University of Reading, UK)

**Overseas research partners:**

Dr. W. Tushemereirwe and Dr. C. Nankinga, Uganda National Banana Research Programme (UNBRP), Kampala, Uganda

Dr. Cliff Gold, International Institute of Tropical Agriculture (IITA), Kampala, Uganda

Dr Ignace Godonou, CABI Africa Regional Centre, Nairobi, Kenya.

**Other UK research partners:**

Dr D Moore CABI Bioscience, UK

**Project Funding:** DFID Crop Protection Programme

**Start and end dates:** January 2001 – March 2004

**Project Purpose:** Benefits for poor people generated by application of new knowledge on crop protection to annual and herbaceous crops in forest agriculture production systems

**Project Justification:**

The banana weevil is a particularly serious pest in Uganda for which no satisfactory (or acceptable) control has yet been devised. Surveys carried out as part of the activities of the National Programme and IITA-Rockefeller have demonstrated the importance given to the banana weevil as a key pest. The IITA-Rockefeller programmes have funded two PhD projects on weevils by Rukazambuga (1996) and Nankinga (1999). These studies confirmed the importance of the pest in terms of plant growth and yield and the possibilities of using a natural biocontrol agent (*Beauveria bassiana*) for its management.

The importance of weevils within the complex of constraints was also emphasised at technical meetings and at workshops held in UK, Uganda and South Africa during 1998/9. The pest is a priority of the Banana Research Network for East and Southern Africa (BARNESA) and the East Africa regional office of International Network for the Improvement of Bananas and Plantains (INIBAP).

The adoption of control measures based on indigenous pathogens becomes a necessary component of the improved environmentally safe methods required. Their achievement requires an understanding of the biological systems and processes. The concept of acquiring or producing effective beneficial organisms and their successful field deployment can be achieved through demonstrations, farmer training sessions, oral presentations, publications and the support of prospective commercial interests.

This research will validate use of the bcas as part of the integrated management strategy for weevils for use by smallholder farmers producing bananas as a livelihood. It will also seek to understand how bcas can be manipulated to favour maximum efficacy, persistence and survival in soil and how appropriate in-country production of this bca of the required quality can be achieved.

**Specific Project Objective:**

The project will validate the use of a biological control agent within an integrated crop management system. Formulations of indigenous entomopathogenic fungi (*B. bassiana*) will be used at the sites selected by the NBRP. Their efficacy in suppressing weevil populations will be assessed and the benefits in crop production recorded.

**List of intended Outputs:**

1. A protocol for deploying different weevil control strategies within one system developed, evaluated and promoted
2. A technique for producing consistent good quality inoculum of *B. bassiana* in an appropriate formulation developed and optimum conditions for deployment described



3. Refinements in the production, harvesting, processing and packaging of the *B bassiana* developed
4. Reports, extension material, radio publicity and refereed papers prepared and delivered.
5. A workshop on IPM technologies in the third year (to cover also the activities of the other DFID-CPP projects)

### Project Logframe:

| Narrative Summary  | Objectively Verifiable Indicators   | Means of Verification                | Important Assumptions  |
|--|---|--------------------------------------|--|
| <b>Goal</b>  |   |                                      |  |
| Enter the Programme Purpose that you are addressing  | To be completed by Programme Manager  | To be completed by Programme Manager | To be completed by Programme Manager   |
| <b>Purpose</b>   |   |                                      |  |
| Enter the Programme Output that you are addressing   | To be completed by Programme Manager  | To be completed by Programme Manager | To be completed by Programme Manager   |
| <b>Outputs</b>   |   |                                      |  |
| 1 A system for integrating different control techniques for banana weevil developed and promoted.  | Farmers from at least one benchmark site adopting weevil control strategy       |                                      | That field sires are made available. That that bcas of required efficacy are produced. |
| 2. Methods of producing <i>B bassiana</i> and delivery system validated.                           | Small-scale production of good quality <i>B bassiana</i> achieved (at Kawanda ) |                                      |  |
| 3. Refinements in methods of production, harvesting, packaging <i>B bassians</i> described.        | Packaged <i>B bassiana</i> evaluated by some farmers at benchmark sites.        |                                      |  |
| 4.Reports, extension materials, radio publicity and refereed papers prepared and delivered         | Half yearly and annual reports; at least 2 publications by end of second year   |                                      |  |
| 5.Workshop conducted to consider success of technologies and further promotion                     | Concluding workshop for this phase of the IPM technologies                      |                                      |  |
| .  |   |                                      |  |
| <b>Activities</b>  | <b>Inputs</b>   | <b>Means of Verification</b>         | <b>Important Assumptions</b>   |
| 1.1 Planning meetings (in UK and Uganda) for rationalisation and co-ordination of activities.      | Total Budget here   |                                      |  |
| 1.2 Design trails at KARI and at benchmark sites.  |   |                                      |  |
| 1.3 Site managers co-ordinate scientific activities with all partners in this and related projects |   |                                      |  |
| 1.4 Evaluate the effects of the IPM techniques on weevil populations,corm damage and yield.        |   |                                      |  |



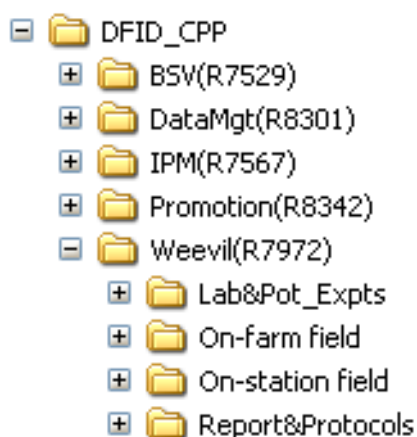
|  |  |  |  |
|--|--|--|--|
| 1.5 Evaluate pheromone lures in traps for delivery of biopesticides  |  |  |  |
| 1.6 Socio-economic analysis of biocontrol agent production and deployment methods  |  |  |  |
| 1.7 Biometric analyses with IITA/DFID biometricians  |  |  |  |
| 2.1 Efficacy and persistence studies and extent of secondary cycling of bcas under field conditions (with farmer participation). |  |  |  |
| 3.1 Trial quantities of B. bassiana produced to high quality standards at CABI Nairobi lab                                       |  |  |  |
|  |  |  |  |
| 4.1 Promotion pathways for IPM techniques identified in collaboration with interested groups.                                    |  |  |  |
| 4.2 Preparation of publicity, reports, demonstrations and papers   |  |  |  |
| 5.1 Planning and organisation of project workshop in 2002  |  |  |  |

Note: Outputs should be numbered 1, 2, 3, etc. Activities should relate to these outputs and be numbered 1.1, 1.2, ...2

### Archive of project data files and documentation

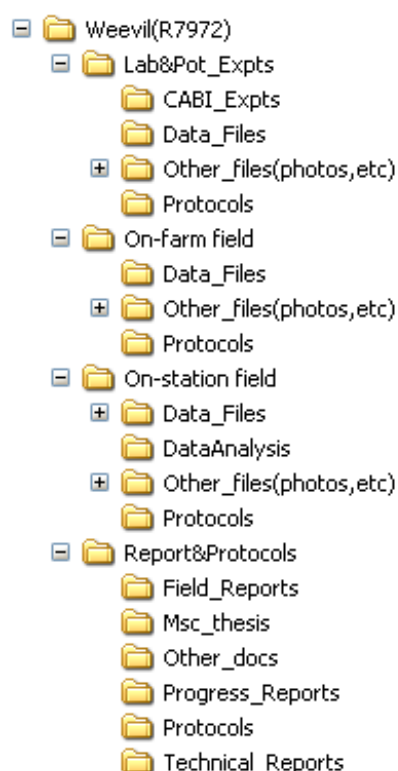
Figure 1 shows the directory structure for inclusion of all project level documentation within the central archive held at KARI, Uganda, while Figure 2 shows relevant sub-directories. Names of data files contained within each of the *Data\_Files* sub-directories are shown in Figures 3a, 3b, 3c, 3d. A list of protocols written for the various studies appears in Figure 4.

**Figure 1. Overall directory structure for archive of project-level data information.**





**Figure 2. Sub-directory structure for archive of Project R7972 information**



**Figure 3a. Data files in the directory \Weevils(R7972)\Lab&Pot\_Expts\CABI\_Expts**




| Name ▲   | Size  | Type                   | Date Modified    |
|--|-------|------------------------|------------------|
| Experiment 2.xls                                     | 14 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 3.XLS                                     | 30 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 4.XLS                                     | 43 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 5.xls                                     | 41 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 6.xls                                     | 28 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 7.xls                                     | 38 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 8.xls                                     | 48 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 9.xls                                     | 69 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 10.xls                                    | 80 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Experiment 11.xls                                    | 95 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| Expertiment 1.xls                                    | 15 KB | Microsoft Excel Wor... | 26/03/2004 12:11 |
| LIST OF EXPERIMENTS IN THE BANANA WEEVIL PROJECT.doc | 66 KB | Microsoft Word Doc...  | 26/03/2004 12:14 |

**Figure 3b. Data files in the directory \Weevils(R7972)\Lab&Pot\_Expts\Data\_Files**














| Name ▲   | Size   | Type                   | Date Modified    |
|--|--------|------------------------|------------------|
| K_Attractiveness_kairomones_buried_tissues.xls       | 32 KB  | Microsoft Excel Wor... | 14/01/2004 07:59 |
| K_Bb_Formulations&SoilAmendmentsLabPot.xls           | 117 KB | Microsoft Excel Wor... | 01/04/2004 14:44 |
| K_Dissemination_Inoculated_noninoculated_weevils.xls | 42 KB  | Microsoft Excel Wor... | 14/01/2004 07:59 |
| K_Dissemination_lab_trap_infection.xls               | 89 KB  | Microsoft Excel Wor... | 28/02/2004 12:34 |
| K_Pilot_tests.xls                                    | 47 KB  | Microsoft Excel Wor... | 03/03/2004 12:19 |








**Figure 3b. Data files in the directory \Weevils(R7972)\On-farm field\Data\_Files**

| Name ▲   | Size  | Type                   | Date Modified    |
|--|-------|------------------------|------------------|
|  Ma_cormdamage data.xls       | 75 KB | Microsoft Excel Wor... | 21/01/2004 10:39 |
|  Ma_Soilanalysis data.xls     | 17 KB | Microsoft Excel Wor... | 13/01/2004 06:53 |
|  Ma_weevilassessment data.xls | 74 KB | Microsoft Excel Wor... | 04/03/2004 11:19 |













**Figure 3c. Data files in the directory \Weevils(R7972)\On-station field\Data\_Files**

| Name ▲  | Size     | Type                   | Date Modified    |
|---|----------|------------------------|------------------|
|  PILOT_DataNoProtocols                         |          | File Folder            | 18/05/2004 09:31 |
|  K_Attractiveness_Dissemination_Kari_Senge.xls | 90 KB    | Microsoft Excel Wor... | 14/01/2004 07:58 |
|  K_Attractiveness_kairomones_mpolo_kayinja.xls | 76 KB    | Microsoft Excel Wor... | 14/01/2004 07:59 |
|  K_Attractiveness_kairomones_recapture.xls     | 87 KB    | Microsoft Excel Wor... | 11/12/2003 14:32 |
|  K_BbSoil_amendments_field.xls                 | 72 KB    | Microsoft Excel Wor... | 14/01/2004 09:38 |
|  K_Meteorological.xls                          | 28 KB    | Microsoft Excel Wor... | 16/01/2004 10:44 |
|  K_Spacing_Agronomy.xls                        | 1,131 KB | Microsoft Excel Wor... | 04/03/2004 12:09 |
|  K_Spacing_Meteorological data.xls             | 52 KB    | Microsoft Excel Wor... | 03/03/2004 11:15 |
|  K_Spacing_soil and plant analysis.xls         | 35 KB    | Microsoft Excel Wor... | 05/12/2003 12:25 |
|  K_Spacing_suckers.XLS                         | 274 KB   | Microsoft Excel Wor... | 21/01/2004 12:56 |
|  K_Spacing_Sunlight data.xls                   | 155 KB   | Microsoft Excel Wor... | 03/03/2004 11:15 |
|  K_Spacing_weevildamage.xls                    | 591 KB   | Microsoft Excel Wor... | 25/02/2004 11:44 |
|  K_Spacing_weevils.xls                        | 953 KB   | Microsoft Excel Wor... | 03/03/2004 11:14 |

**Figure 4. Data files in the directory \Weevils(R7972)\Reports&Protocols\Field\_Reports**

| Name ▲   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
|  Caroline_Msk_Farmers participating in the Beauveria trials.doc | 23 KB  | Microsoft Word Doc... | 14/07/2003 12:59 |
|  Caroline_Msk_Report of B. bassiana trial.doc                   | 27 KB  | Microsoft Word Doc... | 23/07/2003 06:28 |
|  Caroline_Msk_sensitisation.doc                                 | 357 KB | Microsoft Word Doc... | 22/07/2003 06:45 |
|  Caroline_Msk_Third_rpt.doc                                     | 70 KB  | Microsoft Word Doc... | 05/11/2003 07:30 |
|  Report of B. bassiana masaka trial.doc                         | 27 KB  | Microsoft Word Doc... | 18/11/2003 10:34 |

**Figure 4. Data files in the directory \Weevils(R7972)\Reports&Protocols\Protocols**

| Name ▲   | Size   | Type                  | Date Modified    |
|--|--------|-----------------------|------------------|
|  LIST OF EXPERIMENTS IN THE BANANA WEEVIL PROJECT.doc | 66 KB  | Microsoft Word Doc... | 26/03/2004 12:14 |
|  Protocol_Attractiveness_kari_senge_VT6.doc           | 26 KB  | Microsoft Word Doc... | 04/03/2004 07:12 |
|  Protocol_AttractKairomonesRecapture_VT5.doc          | 25 KB  | Microsoft Word Doc... | 04/03/2004 07:06 |
|  Protocol_BbassianaEfficacy_onfarm_CK2.doc            | 63 KB  | Microsoft Word Doc... | 04/03/2004 08:23 |
|  Protocol_BbassianaEfficacy_onstation_CK1.doc         | 128 KB | Microsoft Word Doc... | 04/03/2004 08:16 |
|  Protocol_Dissem_inocul_non-inocu_VT3.doc             | 29 KB  | Microsoft Word Doc... | 04/03/2004 07:06 |
|  Protocol_Dissem_labtrap_infection_VT4.doc            | 30 KB  | Microsoft Word Doc... | 04/03/2004 06:54 |
|  Protocol_Kairomones_Buried_Tissues_VT1.doc           | 30 KB  | Microsoft Word Doc... | 04/03/2004 07:05 |
|  Protocol_Kairomones_Mpolo_Kayinja_VT2.doc            | 27 KB  | Microsoft Word Doc... | 04/03/2004 07:06 |
|  Protocol_SoilAmendments_Lab_ME1.doc                  | 77 KB  | Microsoft Word Doc... | 04/03/2004 06:41 |
|  Protocol_SoilAmendments_on-station_ME3.doc           | 114 KB | Microsoft Word Doc... | 04/03/2004 06:50 |
|  Protocol_SoilAmendments_Pot_ME2.doc                  | 122 KB | Microsoft Word Doc... | 04/03/2004 06:43 |



## Appendix 14

### Abstract of a NARO conference paper<sup>\*</sup>

#### **COLLECTION AND MANAGEMENT OF DATA FROM NARO RESEARCH ACTIVITIES: - A case-study from the Banana Research Programme at KARI -**

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High quality data is absolutely essential if NARO is to produce research that can be relied upon and trusted. This can be achieved if there is a clear data management plan for all activities in a research project. Good data management is a basic requirement within any research process and serves to ensure there is no unnecessary waste in data collection regimes; that good disciplined procedures exist for data cleaning and validation; that there is opportunity for linking interdisciplinary data sets; and that data can be analysed to produce evidence-based research conclusions.

Currently there appears to be no recognition amongst researchers, data users or NARO administrators that a problem exists within their research system with respect to data collection and management. This unawareness and the general lack of policies and guidelines on how to manage research data has the danger of producing poor quality research results from unsound data collection processes and database design. We believe there is an urgent need for a more integrated approach whereby researchers within NARO research programmes work together to completely review and redesign their data management systems from stages of planning data collection activities through to database design and archiving. This paper presents a case-study from the National Banana Research Programme to demonstrate how this may be achieved to enable sound research outputs through a disciplined approach to data quality, transparency and utility.

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<sup>\*</sup> Acceptance of the paper for presentation at the NARO conference in September 2004 has not yet been confirmed.