Socio-economic Report for Project (R8296/ZA0568), Promotion of Sustainable Approaches for the Management of Root-Knot Nematodes on Vegetables in Kenya

Technical Report

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By

R. Musebe[1], P. Dorward[2] and D. Karanja[3]

1 and 3. CABI Africa Regional Centre, PO Box 633-00621, Nairobi, Kenya.

2 Department of Agriculture, The University of Reading, PO Box 237,

Reading, RG6 6AR, UK

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1.0 Introduction

This report covers the following activity 3.2 of the project:

> **Conduct ongoing farmer assessment of technologies, including participatory planning in the use of BCAs and resistant varieties within their own farms/crop rotations and factors that encourage or constrain adoption**

A separate report covers the other main socio-economic activity (activity 4.1) regarding the future uptake of Biological Control Agents (BCAs). The root-knot nematode project aims at verifying and promoting sustainable approaches for the management of root-knot nematode (*Meloidogyne spp.*) through incorporation of naturally occurring microorganisms with cultural techniques such as crop rotation and use of resistant varieties.

In order to accomplish the objectives of the project, on-farm trials were set up in Mwea and Kibirigwi. These are areas known for tomato production for both commercial and home consumption. The trials involve the use of BCAs i.e. *Pasteuria penetrans* and *Pochonia chlamydosporia*, crop rotation and tomato varieties with resistance to root-knot nematodes. The on-farm trials were participatory and involved farmers practicing organic and inorganic farming. The first category consisted of farmers from Maragua practicing organic farming under rain fed conditions. The second category was inorganic farmers from Kibirigwi practicing production under rain fed and irrigation conditions and farmers from Mwea practicing production under irrigation.

The farmer participation was aimed at ensuring sustainability of the technologies. This involved participation by the farmers in all aspects of assessment of the technologies. To this end socio-economic assessments involving the farmers were undertaken.

2.0 Objectives of the assessments

1. To identify and score characteristics used by farmers when comparing/selecting tomato varieties
2. To assess the relative performance of specific tomato varieties
3. To describe the existing rotations and explore how BCAs/rotations could fit in
4. To enable farmers to assess the BCAs/rotation trials
5. To identify factors that encourage or constrain adoption of the technologies

3.0 Methodology

The assessments were conducted in three phases. The first phase involved a preliminary assessment of the varieties, while the second phase was the final assessment of the varieties and the third phase was the assessment of the biological control agents. The assessment commenced with the introduction of all the participants including the research team and the farmers. The main approaches used to accomplish the objectives were focus group discussions with participatory methods eg scoring and ranking. Some specific questions were asked and allowance given for discussions in an open and free environment that encouraged total participation of all the farmers present. The number of farmers who participated for specific group field days during the preliminary assessment on 8th, 15th and 28th April 2004 was 9, 21 and 18 for Kibirigwi (irrigated), Kibirigwi (rain fed) and Mwea (irrigated), respectively. The number of farmers that participated in the joint field day in the afternoon of 28th April, 2004 was 17, 14, 10 and 18 for Kibirigwi (irrigated), Kibirigwi (rain fed) and Mwea (irrigated), respectively. A formal questionnaire was used to investigate possible factors which encourage or constrain adoption.

The production regimes involve exclusive use of irrigation in Mwea, while in Kibirigwi there is production under irrigation and rain fed conditions. Two sites were visited in Kibirigwi for irrigated and rain fed production systems on 8th April and 15th April 2004 to achieve the first and third objective. The field visit in Mwea was held on 28th April 2004 and had two sessions. The first session, which was held in the morning, was exclusively for Mwea farmers practicing production under irrigation. It was meant to achieve the first and third objective as was the case for Kibirigwi. The second session was conducted in the afternoon to achieve the second objective. Assessment of the varieties by the Nyagithambo organic farmers was conducted on 18th June 2004. The organic farmers practice tomato production under rain fed conditions. A final assessment of the varieties was conducted on 18th June 2004 with all the farmers. Assessment of the biological control agent trials was conducted on 1st September, 2004 with all the farmers

4 Results of evaluation of resistant tomato varieties

4.1 Identification and scoring of characteristics for selecting tomato varieties

Four tomato varieties that have some resistance to nematodes are being tried with farmers through on-farm trials. The experiment was laid out in a complete randomized block design (CRBD) with four treatments i.e. tomato varieties namely Cal J, Monyala, Caltana and Nemonetta and three replicates (blocks). The tomatoes were irrigated individually as opposed to the furrow irrigation used in other areas of Mwea. The costs of seeds for the varieties were: Cal-J (50g) – Kshs. 360, Monyala (10g) – Kshs. 1590, Caltana (10g) – Kshs. 1590, Nemonetta (1000 seeds) – Kshs. 5000.

Farmers developed a listing of the characteristics they consider to be important for selection of a good tomato variety. Subsequently, scoring and then ranking was done to indicate the relative importance of each of these characteristics. These characteristics included yield, marketability (consumer preference), size of the tomato (medium was preferred), firmness, weight, colour (red preferred), resistance to diseases and pests, vigour of the plant, period to maturity, length of harvesting period and shape (oval preferred). Each of the characteristics received scores ranging from 1 to 5, where 1 represented least importance and 5 represented maximum importance. All the scores from the three groups of farmers for each characteristic were used to calculate a mean score. On the basis of the mean scores ranks were given to the characteristics. Farmer ranking indicated marketability to be the most important characteristic followed by yield/size and colour (Table 1).

Table 1: Farmer scoring of tomato selection characteristics

Characteristic	**Score**				**Rank**			
	Kibirigwi (Irrigated)	Kibirigwi (Rainfed)	Mwea (Irrigated)	Average score	Kibirigwi (Irrigated)	Kibirigwi (Rainfed)	Mwea (Irrigated)	Agreed rank
Marketability	5	5	4	4.67	1	1	2	1
Yield	4	3	5	4.00	2	3	1	3
Colour	4	3	1	2.67	2	3	6	4
Resistance to diseases and pests	4	5	4	4.33	2	1	2	2
Firmness	3	3	3	3.00	3	3	3	5
Size	3	4	5	4.00	3	2	1	4
Weight	2	1	3	2.00	4	5	4	8
Vigour	2	3	2	2.33	4	3	3	9
Shape	2	2	4	2.67	4	2	2	6
Maturity period	2	3	2	2.67	4	4	3	7
Harvesting period	2	2	1	1.67	4	3	3	6

The scores given by the farmers were subsequently used in gauging the performance of different tomato varieties. Farmers made some requests after scoring and providing the corresponding ranking. Among these were that another experiment be conducted in Kibirigwi to enlighten other farmers that may not have benefited from the existing experiments. It was also envisaged that this would extend the technology to other farmers.

4.2 Preliminary assessment of the relative performance of different tomato varieties

An assessment of the performance of the test varieties was conducted by farmers from Kibirigwi and Mwea. It was conducted at the Mwea on-farm trial site in the afternoon, on 28th April 2004. Prior to the assessment, there were introductions of all persons present. In addition, the contact farmer from Mwea explained the design and management of the trial to the rest of the farmers. The assessment was done based on the characteristics identified by the farmers as important in the selection/comparison of varieties of tomatoes. Given the stage of the crop, only six characteristics were used for the assessment. These were size, shape, maturity period, vigour, weight, and disease and pest resistance. The assessment procedure had two stages. The first stage involved farmers providing relative scores for each of the above characteristics for each variety. In the second stage the scores were then weighted on the basis of importance attached to each characteristic (Table 1) and then aggregated to obtain the performance level for each variety (Table 2).

Table 2: Preliminary performance of different tomato varieties

Characteristics	Cal J		Monyala		Caltana		Nemonetta		Weight factor
	Raw Score	Weighted score	Raw Score	Weighted score	Raw Score	Weighted score	Raw Score	Weighted score	
Size (4.00)	4	0.88	5	1.1	4	0.88	3	0.66	0.22
Shape (2.67)	1	0.15	3	0.45	3	0.45	5	0.75	0.15
Maturity period (2.67)	2	0.30	4	0.60	3	0.45	2	0.30	0.15
Vigour (2.33)	2	0.26	3	0.39	3	0.39	2	0.26	0.13
Weight (2.00)	3	0.33	2	0.22	4	0.44	3	0.33	0.11
Disease and pest resistance (4.33)	3	0.72	2	0.48	1	0.24	3	0.72	0.24
Weighted average	-	2.64	-	3.24	-	2.85	-	3.02	-
Rank	4		1		3		2		-

Note: The relative importance of each characteristic is given by the scores in the brackets. The corresponding weight factors are ratios of the scores of each characteristic to the total number of scores for all of the characteristics. The weighted scores are the product of the weight factors and the raw scores.

From the initial assessments conducted by the farmers the variety that performed best was Monyala and the worst performer was Cal J.

4.3 Final assessment by farmers of the relative performance of different tomato varieties

An assessment of the performance of the test varieties was conducted using the characteristics identified by the farmers. Prior to the assessment the contact farmer from Mwea explained the design and management of the trial to all the farmers. Farmers were also shown records of the yields for specific varieties. The farmers subsequently inspected the field (Figure 1) under the guidance of the contact farmer before commencement of the ranking exercise.

Figure 1: Farmers inspecting the crops before the ranking exercise

Matrix scoring of the varieties was undertaken by asking all the farmers to assign a score for each characteristic in respect of each of the varieties. The maximum number of points (scores) allocated to each variety was 4. The scoring exercise stimulated a discussion among all the farmers. The discussion led to a consensus on scores for specific characteristics of each variety, which were tallied on a master sheet (Figure 2).

Figure 2: Farmers discussing the ranking of varieties

The exercise was repeated for all characteristics for all varieties. All the scores were then summed up. The variety with the highest score was then taken as the best.

4.3.1 Assessment by Nyagithambo Organic farmers

A total of 10 farmers (3 men and 7 women) from the Nyagithambo Organic Farmers Self Help Group in Maragua District attended the meeting. The group consisted of farmers that have undergone or are undergoing training by the Kenya Institute of Organic Farming (KIOF).

The organic farmers identified the characteristics that are important to them in the selection of tomato varieties. Simple ranking was used to enable the farmers to come to consensus in developing a ranked list of characteristics. Since there were 6 characteristics the highest score was 6. This score was given to the highest ranked characteristic and the next highest number to the next highest characteristic until all the characteristics were considered. The rankings for each farmer were then picked and tallied on a master sheet. The total scores for each characteristic were used to put them in order of importance. Using this approach, the characteristics were ranked in order of importance starting with the most important as: resistance to pests and diseases, firmness of the fruit, yield, size, colour and shape. There was a consensus among all the farmers regarding the final ranking of the varieties based on the summation of the scores.

According to the assessments Monyala emerged as the best variety and Cal-J was rated the worst performer (Table 3).

Table 3: Matrix scoring of the varieties by the organic farmers

Characteristic	Cal-J	Nemonetta	Monyala	Caltana
Yield (4)	1	3	4	2
Size of tomato (3)	2	2	4	3
Firmness (5)	4	1	2	3
Colour (2)	1	4	3	2
Resistance to disease and pest (6)	1	4	3	2
Shape (1)	2	1	4	3
Total scores	40	56	66	51
Rank	4	2	1	3

Note: The relative importance of each characteristic is given by the scores in the brackets. The total scores are a summation of the product of the characteristic scores and scores for individual varieties.

4.3.2 Assessment by Mwea and Kibirigwi inorganic farmers

There were 9 farmers (3 women and 6 men) from Kibirigwi irrigation and 8 farmers (2 women and 6 men) from Kibirigwi rain fed. There were 8 men and 4 women farmers from Mwea. The same characteristics identified by the farmers were used for evaluating the varieties under experimentation. Farmers awarded scores to the varieties on the basis of selected characteristics (Table 4).

Table 4: Matrix scoring of the varieties by Mwea and Kibirigwi farmers

Characteristic	Cal-J	Nemonetta	Monyala	Caltana
Yield (4.00)	1	2	4	2
Marketability (4.67)	1	2	4	2
Size of tomato (4.00)	1	4	2	3
Firmness (3.00)	1	4	3	2
Colour (2.67)	1	2	4	3
Resistance to disease and pest (4.33)	2	3	4	1
Shape (2.67)	2	1	4	3
Harvesting frequency (1.67)	1	4	3	2
Total scores	34.01	73.02	95.37	59.03
Rank	4	2	1	3

Note: The relative importance of each characteristic is given by the scores in the brackets. The total scores are a summation of the product of the characteristic scores and scores for individual varieties.

The four groups of farmers had the same ranking for the varieties. Monyala had the best rank while Cal-J had the worst performance in terms of ranking. After ranking, discussions were held with the farmers to elicit their perception about the varieties. The farmers' views were that:

1. Nemonetta was good but it was growing too high and had very large fruits. They suggested that it would be better to breed for medium height and size for this particular variety. It would be better for home consumption or kitchen gardening. It was also noted that it is a sweet variety.
2. Monyala was rated best overall. It appeared long lasting and heavy yielding according to the farmers.

Farmers did not raise any issues about Caltana and Cal-J other than noting that these were not as good as Nemonetta and Monyala. Cal-J had worst performance.

4.4 Traders assessment of different tomato varieties

A participatory approach involving ten traders (middlemen) ie five female traders and five male traders, was used to assess the performance of nematode resistant tomato varieties. Assessment used the characteristics identified by the traders as most crucial in the selection of tomatoes. Each of the varieties was given a score depending on its performance on the basis of specified characteristics.

Simple ranking was used for prioritizing the characteristics. Initially the traders were asked to give a list of the characteristics used while buying the crops from the farmers, for sale. Based on the total number of characteristics, the most important characteristics was assigned a score equivalent to the total number of characteristics, and then the next best was assigned a score equivalent to the total number of characteristics less one. This scoring was continued until all the characteristics were finished. After identifying the characteristics an assessment of the varieties was done by matrix scoring. In this case varieties were given scores corresponding to each of the characteristics. After assigning scores for all characteristics for all the varieties, an aggregation of scores was done and the variety with the highest number of scores was given the first rank. The variety with the next highest number of scores was given the second rank. The ranking continued as such until all the varieties were catered for. According to the middlemen's assessment Monyala was rated the best while Cal-J was the worst (Table 5).

Table 5: Variety assessment by middlemen

Characteristics	Weight factor	Cal-J		Nemonetta		Monyala		Caltana	
		Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score	Raw score	Weighted score
Consumer preference (1)	0.05	2	0.10	1	0.05	4	0.20	3	0.15
Size (medium) (5)	0.24	2	0.48	1	0.24	4	0.96	3	0.72
Firmness (shelf life) (3)	0.14	1	0.14	4	0.56	3	0.42	2	0.28
Weight (6)	0.28	1	0.28	4	1.12	3	0.84	2	0.56
Colour (red) (4)	0.19	1	0.19	3	0.57	4	0.76	2	0.38
Shape (oval) (2)	0.10	2	0.20	1	0.10	4	0.40	3	0.30
Weighted average	-	-	1.39	-	2.64	-	3.58	-	2.39
Rank	-	4		2		1		3	

Note: The relative importance of each characteristic is given by the scores in the brackets. The corresponding weight factors are ratios of the scores of each characteristic to the total number of scores for all of the characteristics. The weighted scores are the product of the weight factors and the raw scores.

The middlemen noted that the tomatoes are usually put in five grades, in which the top grade fetches the highest amount. The farm gate price for the top grade, which is grade 1, was an average of Ksh. 500 per crate, while the average price for the lowest grade (5) was Ksh. 100 per crate (Table 6). In most cases the middlemen do not separate the tomatoes according to the varieties. The tomatoes are graded depending on the specified characteristics and especially size and weight but not on the basis of varieties. The current field exercise has enlightened the middlemen. Their understanding now is that by purchasing Monyala they are likely to get higher net profits.

Table 6: Farm gate prices for the various tomato grades per crate (60 kg) (13/8/2004)

Tomato grade	Farm gate prices (Kshs.)	Price in Nairobi (Kshs.)
1	500	1300
2	400	1200
3	300	1100
4	200	1000
5	100	900

Most of the middlemen sell their tomatoes in Nairobi, although a few middlemen noted that they sell their tomatoes in Mwingi District. The transaction costs, including transport and other levies imposed on the tomatoes, varied depending on where each middleman would sell their tomatoes. The middlemen noted that they always ensured that they purchase tomatoes and sell to generate at least a reasonable profit margin to allow continuity of their business.

4.5 Harvesting, yields and gall indices of tomato varieties

All the farmers were involved in the harvesting and grading of tomatoes. Harvesting was done for all the varieties for each block (Figure 3). The harvested tomatoes were placed in containers designated for each variety.

Figure 3: Farmers harvesting the tomatoes

After harvesting the tomatoes were first sorted into marketable and non-marketable. The marketable tomatoes were further put into five grades, where grade 1 was the best while grade 5 was the least based on size, shape and colour. The fruits from the guard rows were not graded. Weights for all the grades were subsequently measured, using a kitchen balance, by the farmers and recorded (Figure 4).

Figure 4: Farmers weighing and grading the tomatoes

After harvesting, grading and weighing the tomatoes were sold. Tomatoes are usually sold in crates, which weigh approximately 60 kilograms at a farm gate price ranging from Ksh. 100 to Ksh. 500 per crate.

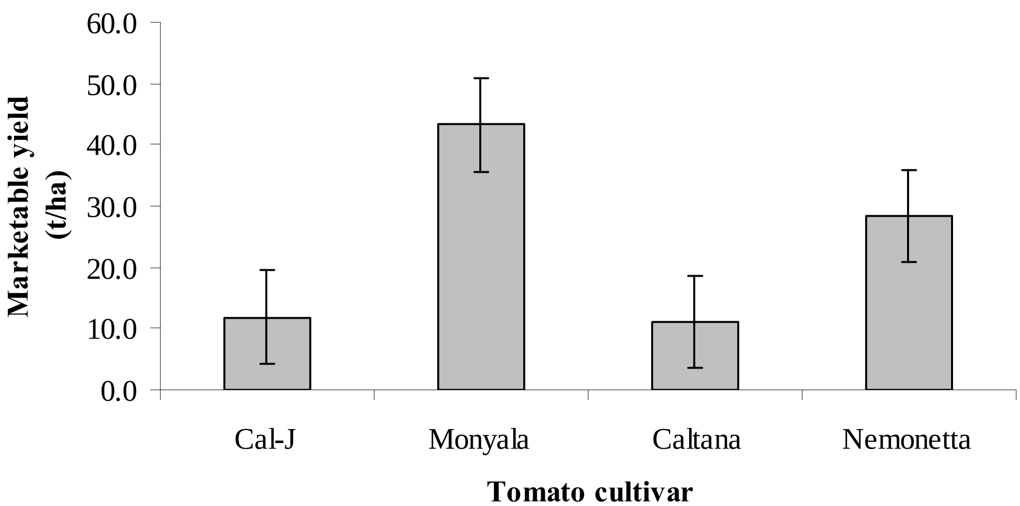

Figure 5: Marketable yield of different tomato cultivars evaluated for resistance to root-knot nematodes at Mwea, Kenya.

Monyala performed best and and Nemonetta had the second highest yield. An important finding is that there is an inverse relationship between susceptibility to nematodes and marketable yield. The mean gall indices for Cal-J and Caltana were higher while for Monyala and Nemonetta were low (Figure 6). The actual level of infestation (x) is an average computed from ten plants.

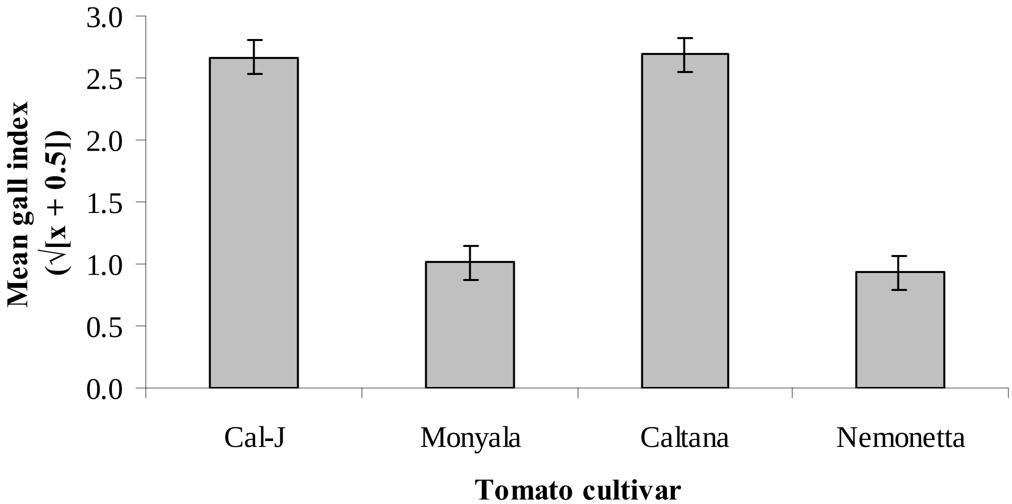

Figure 6: Root-knot nematode gall index on different tomato cultivars at Mwea, Kenya.

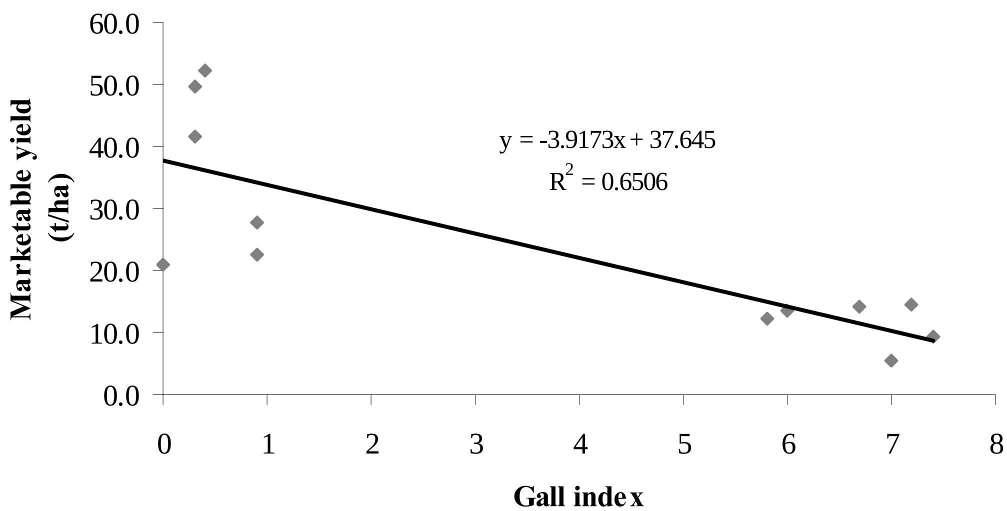

Figure 7: Correlation between gall index and marketable yield of tomatoes infested by root-knot nematodes at Mwea, Kenya.

It is interesting and important to note that the order in which the resistant varieries were ranked by the middlemen and by famers (at both stages of growth) and the levels of yields and reduced infection measured for the varieties all agreed. The findings this far indicate that promotion efforts should target Monyala.

5.0 Results of description of existing rotations and exploration of could how BCAs/rotation could fit in

This involved a review of: current production practices; production constraints; control of root-knot nematodes; practices being promoted by the project and findings from the on farm trials. This was followed by exploration of how the BCAs/rotation practices could be incorporated into farmers cropping systems.

Using the method of group discussion, the research team went through each of the issues indicated above. The farmers had an opportunity to explain how they undertake crop rotation activities and other production practices including crops used in the rotations and reasons for the choice of crops. The current production practices were mainly rotation of the tomato crop with other crops such as cabbage, maize, sweet potatoes, French beans, onions and other vegetables. There was application of fertilizers and spraying of inorganic pesticides, in some cases, depending on the farmer capacity. There was staking and bird scaring where it was found necessary. Tomato production is done under rain fed conditions and irrigation. There was direct sowing of seeds and transplanting. Rain fed production is done in two seasons, which are the long rains from April to August and the short rains from October to December. September is usually a fallow period.

Table 7: Responses on rotations, constraints and nematode control from different locations

Location	**Crop rotations**	**Production constraints**	**Nematode control**
Mwea (irrigated)	French beans, potatoes and field beans	Bacterial wilt, nematodes, blight, lack of capital marketing, impure seeds, low pesticide efficacy, mites, cut worms, whiteflies, thrips and rust	Main control is use of ash and trash burning. Mexican Marigold and *Crotalaria spp.* are also used. There is very limited use of nematicides.
Kibirigwi (irrigated)	Cabbages, maize, other vegetables, sweet potatoes, French beans and onions.	Nematodes, bacterial wilt, canker, blight, whiteflies, thrips, spider mites and blossom-end rot	No control and /or limited use of ash.
Kibirigwi (rain fed)	Maize, sweet potatoes and beans.	Bacterial wilt, nematodes, blight, rust, white flies, aphids, thrips and red spider mites.	No control. In most cases, there is limited control by ash and trash burning
Nyagithambo (organic)	Cabbage, onions, field beans, maize, sweet potatoes, cow peas and egg plant,	Bacterial wilt, nematodes, blight, marketing, boll worms, birds, yellowing of leaves	Main control is ash. Trash burning, crop rotation, hot water treatment, Mexican marigold, double

		and blossom-end rot.	digging (solarization) and pymac.

The production constraints for all the categories of farmers were listed as bacterial wilt, nematodes, bacterial canker, spider mites, viruses, whiteflies, aphids, *Fusarium* wilt, thrips, blight (early and late), blossom-end rot, marketing problems, lack of capital and poor quality seeds. Bacterial wilt was noted to be the most serious constraint, followed by nematodes, under rain fed conditions in Kibirigwi and undr organic farming and irrigated conditions in Mwea. Under irrigated conditions in Kibirigwi, farmers ranked nematodes as the most serious constraint in tomato production, followed by bacterial wilt. This underscored the importance of efforts to forestall the deleterious effects of nematodes on tomatoes. Farmers explained how they control nematodes and other pests and diseases. This involves the use of fungicides, insecticides, regular watering, crop rotation with maize and use of ash. Nematodes were controlled using ash, trash burning, pyrethrum extract (pymac) and trap crops such as *Crotalaria* spp. and Mexican marigold. The use of Mexican Marigold was reported by some organic farmers and some Mwea farmers that had participated in an earlier CABI project. Ash is applied after planting or is incorporated with the manure in the seed bed before sowing. A few chemicals such as Morcap® are used but in general chemical control is rarely used. This is because the chemicals are either banned or have low efficacy. For example, Furadan has restricted use because of toxicity, while Nemacure is considered as having declining efficacy. Farmers indicated that the indigenous control method, which involves using ash, was not effective. It was clearly apparent that nematode control was a problem and farmers were eager to obtain alternative control methods.

An overview of the practices being promoted by the project was provided to elicit farmers' interest and indicate the need for mutual participation in the drive to reduce the root-knot nematode problem. In addition, this was to help farmers to identify how these practices fit into their current production practices. The technologies being considered are use of BCAs (*Pasteuria penetrans* and *Pochonia chlamydosporia)* and crop rotation using cabbages.

Farmers had several suggestions on how the BCAs / rotations should be undertaken in order to maximize the benefits from the research activities. In addition to cabbages they suggested use of maize, sweet potatoes and French beans as alternative rotation crops. Sweet potatoes required less labour and were noted to be less susceptible to nematodes meaning that no control was needed. Maize was thought of as a rotation crop because it is a major food crop. Maize is also preferred because it uses residual fertilizers, hence no fertilizers are applications are made. No reasons were attributed to the use of French beans, but the research team discouraged the use of French beans because it is a host for nematodes. Farmers also requested information on alternative rotation crops that would mature within three months or generate sufficient income. It was indicated that the crop to be used as a rotation crop should be one that encourages proliferation of the BCAs. Regarding the BCAs, the farmers expressed concerns about availability, accessibility and the cost implications. Whereas they indicated appreciation of the BCAs, they requested to be told how the BCAs could be found and the costs involved. This raises questions regarding BCA production, the requisite amounts and costs. The need for computation of input costs, especially seeds, was also pointed out. Exchange visits were also requested in order to facilitate sharing of information. Farmers indicated the need for proper communication channels or links between researchers/ extension staff and the farmers themselves. Similarly, the dissemination materials such as books and leaflets require to be simplified. Rethinking and remodeling issues as suggested by the farmers in a participatory manner may be a way forward in ensuring that farmers reap maximum benefits from the practices being promoted.

6.0 Results of assessment of the biological control agents (BCAs) trials

Smallholders (and commercial producers) have highlighted root-knot nematodes as significant constraints to vegetable production. From a sample of 142 farmers, 20% use nematicides (Oruko and Ndung'u, 2001). Smallholders in the Kenya Organic Farmers Association and a group of commercial growers in Mwea have already demonstrated interest in root-knot nematode control by biological methods, provided that a suitable delivery pathway can be found and the technologies can be provided at an appropriate (low) cost. It is against this background that the BCAs trials were started under the add-on root-knot nematode project. Farmers were involved in a participatory manner throughout the experiment and asked to rate the performance of BCAs compared to their own production practices.

A participatory approach involving all the three categories of farmers was used to compare the performance of BCAs/rotations with the normal practice. Farmers were involved in application of BCAs, transplanting of tomatoes and other production practices. An explanation of the treatments was also given to the farmers. This was in order to enable the farmers to appreciate the concept of biological control. There was a meeting with all farmers at flowering and during harvesting to look for visual differences. A description of the existing rotations and an explanation of how BCA/rotation fits in were also done during this stage. Farmers were also involved in harvesting, recording yields, grading and pricing of tomatoes.

A final meeting was called to achieve the following:

1. Recap/explain how BCA/rotation work and wider benefits e.g. safety, benefit to subsequent crops
2. Recap on rotations needed for BCA
3. Visually summarize results of the experiment, especially yields
4. Obtain crucial characteristics for ranking technologies
5. Score BCAs vs. normal practice

For the comparison of BCAs and the current/normal farmer practice ten characteristics were identified by the farmers as crucial. The production practices were awarded scores on the basis of their capacity to provide the specified characteristics. A score of 2 meant that the production practice was superior in terms of providing the specified characteristic and 1 meant that it was inferior in terms of proving the specified characteristic. Using this approach the farmers rated BCAs vs. normal practice (Table 8).

Table 8: Ranking of BCAs vs. normal farmer practices

Characteristic	**Organic farmers ranking**		**Inorganic farmers ranking**	
	BCAs score	Normal practice score	BCAs score	Normal practice score
Yield	2	1	2	1
Resistance to pests	2	1	1	1
Vigour of plants	2	1	2	1
Harvesting period	2	1	2	1
Shape of the fruit	1	1	1	1
Colour	1	1	1	1
Weight	2	1	2	1
Resistance to diseases	1	1	2	1
Size of the fruit	2	1	2	1
Shelf life	1	1	1	1
Total scores	**16**	**10**	**16**	**10**

On average the farmers prefer the BCAs trials to their own production practices. They are however indifferent about their own practices and the BCAs with respect to certain characteristics. Among these are resistance to pests, shape of the fruit, colour of the tomatoes, and shelf life

7.0 Factors that encourage or constrain adoption the technologies

Individual farmer interviews were used to identify the factors that affect the adoption of nematode control technologies. A random sample of 57 farmers was interviewed to provide the data. The farmers were selected from the administrative lists of the households located within the vicinity of the on-farm trials. The selected farmers were interviewed using structured questionnaires to provide information on tomato production practices, production constraints, level of education and willingness to try the technologies. Details of the data collected are as in the questionnaire appended to this report. Data collected were analyzed using descriptive statistics.

7.1 Factors that encourage or constrain adoption of BCAs / rotations

Most of the farmers (80%) grow tomatoes for commercial purposes. As a consequence they need to maximize returns to continue being in business, improve their livelihoods and meet other financial obligations. The production of tomatoes is reduced by nematode infestation.

A majority of the farmers (96.5%) know that nematodes exist and are aware of the tomato losses attributed to nematodes. The ability to forestall the losses is weakened by the inability of farmers to control the nematodes. The existing nematode control methods are not able to curtail nematodes. The current approaches for controlling the nematodes include crop rotation, trash burning, use of ash and limited application of nematicides.

The high costs of nematicides and the low efficacy of some nematicides will encourage farmers to adopt the new technologies, which have a relatively low cost. Most of the farmers do have adequate capital to purchase the nematicides, which are now considered to be the most appropriate approaches. Most of the farmers (86.1%) do not control nematodes at all.

Farmers indicated that they lack a suitable and affordable control method for the nematodes. Currently some farmers use double digging but they report that this approach is labour intensive and whenever they undertake trash burning it affects the entire plot or farm against their interests. Farmers have interest in trying the technologies.

There is an increasing trend in occurrence of nematodes in the farms as reported by 89.5% of the farmers. The appreciation of an increase in nematode population in the farms is likely to encourage adoption of technologies that can help alleviate the problem.

Farmers acknowledge that there is an increase in production due to the new varieties. 84.2% of the farmers interviewed indicated that they expected an increase in production due to the new varieties.

Buyer preference for some of the varieties may encourage adoption of the technologies. For instance the ranking by the traders indicated their preference for onyala. Since most of the tomato farmers undertake the exercise for commercial purposes it is likely that they may take up Monyala earlier than any other variety.

Technical know-how and level of education will encourage adoption of the technologies. The level of farmer willingness to try the nematode resistant varieties and the BCAs increases with the level of formal education of the farmer.

Gender of the household head has direct implications for adoption. Male farmers were more likely to try the new technologies. This may be attributed to the existing extension system that is biased in favour of the male farmers and the fact that more male farmers are involved in commercial farming.

Tomato production involves the use of various inputs and at the same time tomatoes are very perishable commodities. This means that timing of activities is very crucial. Some of the inputs are very costly. The seeds for the nematode resistant varieties are noted to be costly meaning that the high seed costs are likely to stop farmers from adopting the technologies. This is likely to be an issue given that already some farmers (59.6%) are already indicating that the costs of the seeds of existing tomato varieties are high.

Marketing of the tomatoes is major problem to most of the farmers (61.4%). The problems associated with marketing include low prices and the selective behaviour of the middlemen. Similarly, the transportation cost to the key marketing centre (Nairobi) is high. Given that most of the farmers grow tomatoes for commercial purposes a ready market is of immense importance. In this regard information on market prices in various market places and the availability of marketing middlemen is crucial. Farmers are rational decision makers and are unlikely to enter into production of new commodities unless a market is assured. The practical implication here is that all stakeholders will have to encourage and promote the varieties through the use of appropriate approaches and systems.

Availability of the seeds and the BCAs is a factor that will curtail adoption. As of the time of the final evaluation of the technologies it was still not apparent as to how the BCAs will be made available or the cost implications. The seeds of the nematode resistant varieties are as yet not readily available.

Performance of the varieties and the BCAs being promoted will influence adoption. 68.4% of the farmers indicate that Nemonetta is better than their varieties, while 87.7% of the farmers say that Monyala is better than their varieties. 47.4% of the farmers indicate that Cal-J and Caltana are worse than the varieties that they are now growing. Regarding the use of BCAs, 45.6% of the farmers indicated that they are better than their current practices, while the remainder of the farmers were indifferent between BCAs and their own practices.

Awareness regarding the technologies may affect adoption. Whereas 84.25% of the farmers are aware of the nematode resistant varieties, only 49.1% are aware of the BCAs. This means that the promotion efforts would be very crucial to ensure adoption of these technologies, especially the BCA.

Farmers' perceptions and willingness to try the new varieties and the BCAs is variable. Out of all the farmers interviewed only 47.4% indicated that they would try the BCAs if they are made available. The percentages of farmers willing to try Monyala, Nemonetta, Caltana and Cal-J were 86.0%, 68.4%, 8.8% and 7.0% respectively. It therefore likely that given availability of the seeds and the BCAs the farmers would start by trying the Monyala variety. This assertion is also attributed to the fact that the buyers and by implication the consumers have a preference for Monyala.

8.0 Conclusions

The participatory farmer assessments of the technologies together with the exploration of farmers' intentions regarding adoption and factors that encourage or constrain this, were conducted to facilitate adoption, ensure that the technologies were appropriate to farmers practices and systems and to improve understanding of factors likely to influence adoption. Farmers appeared to assess the technologies from two perspectives. These were the farmers' own demand for specific technology characteristics and the ability of the technologies to supply the stated characteristics. Assessment of the factors that constrain or encourage adoption elicited individual and group views.

According to the farmers Monyala had the best performance while Cal-J had least performance. Nemonetta was the second in ranking while Caltana was the third. Interestingly the results of the assessment from the farmers agreed with those from the traders. This is as expected because most of the farmers (80%) produce tomatoes for commercial purposes. Farmers preferences agreed with yields which in turn coincided with levels of resistance evident from assessing infestation. The levels of willingness to try the new varieties ascertained from the survey reflected the above as well and showed very high proportion of farmers wanting to try Monyala and Nemonetta. These should now be promoted in the area and could improve production significantly. The farmer willingness to adopt BCAs was lower compared to the nematode resistant varieties but still important at just under 50%. It is likely that the resistant varieties would be adopted faster than the BCAs.

A number of factors could to interfere with the farmers' intentions to produce the new varieties. Among these are the high costs and availability of the seeds. To facilitate adoption it will be necessary to make the seeds more readily available and packaged in different quantities including small quantities that would be more affordable for the various categories of farmers. Regarding the BCAs farmers are not aware of where to find them and the costs involved. This needs to be addressed and again packaging in small quantities for farmers to try and that are affordable will be important. The technical know-how regarding use of BCAs/rotations also has to be provided given that it is a new approach. These findings have importatant implications for seed suppliers, agrochemical suppliers, extension services and NGOs and need to be addressed as a high proportion of farmers are willing to adopt one or more of the technologies and they have the potential to improve tomato production and farmers livelihoods. Further important issues regarding factors influencing adoption and implications for promotion are given in the other socio-economic report from this project (McKemey, 2005) which explores potential uptake.

References

McKemey, K. (2005) Future uptake of Biological Control Agents by tomato growers in Kenya to control nematodes. Technical report for DFID project R8296/ZA0568. The Department of Agriculture, The University of Reading.

Appendix: Questionnaire for factors that constrain or encourage adoption of technologies

Section A: IDENTIFICATION

District: ----------------------- Division ------------------- Location -----------------------------
Sub-location ------------------------ Village ------------------------------
Farmer's name: ---
If not farmer, respondent's relationship --
Type of farming system (irrigation, rain fed) specify ---

Section B: HOUSEHOLD AND SOCIO-ECONOMIC CHARACTERISTICS

1. Age of household head: …………….. years
2. Sex of household head (tick answer) male -------- female --------
3. Formal education - highest level attained (tick answer):
   a) non-formal education --------- b) primary --------------- c) secondary ---------
   d) higher education --------------- e) other (specify) ---------------------------------
4. Occupation of head of household: ……..………………………………………………..
5. Occupations of spouse of household head ………………………………….
6. Household size: male ---------- female ------------ children --------
7. Asset ownership (number): land owned (acres) -----------------------------
   land rented (acres) ……… cows ………….. goats ………… car …………
   bicycle ……….. donkey ……….. ox-cart ………..
   Other (specify) ---
8. What are the major crops and enterprises that you are involved in, percentage income from each and rank?

Crop/enterprise	Rank currently	Income from crop	Percent income from crop

SECTION C: TOMATO PRODUCTION

9. Is production under irrigation or rain fed? (Specify) ---------------------------------
10. Are you an organic or inorganic (use pesticides) farmer ------------------------------
11. How long have you been practicing tomato farming? ……………. Years
12. Please indicate the area under tomatoes --
13. Please indicate the inputs used in tomato production, input costs and problems.

Type of input	**Cost**	**Any problems associated with the use of the input**
Seeds		
Fertilizer (CAN, DAP, NPK, Urea, foliar feed)		
Pesticides: nematicides		
fungicides		
insecticides		
Irrigation		

14. What is the average production in kilograms or crates? Specify (small =60 kg, large =90 kg) ---------------------------
---------------- Crates or --------------- Kgs
Price per crate -------------- or price per Kg -------------

15. For what purpose do you grow tomatoes? (subsistence, commercial, both etc) -----

16. What are the production constraints? List in order of importance the major constraints in tomato production

Constraint	**Rank**	**interventions used currently**

SECTION D: INCIDENCE AND LOSS FROM NEMATODES

17. Do you know nematodes? Yes/No ----------------------------------
18. In your view what is the trend of occurrence of this pest over years? (tick answer) a) increasing, b) decreasing, c) no change
19. Do you control nematodes? yes/no ---------------------------------------
20. If yes how do you control them--

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21. What problems do you encounter in trying to control nematodes? ----------------
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SECTION E: VARIETY ASSESSMENT

22. Please indicate the tomato varieties grown and reason.

Tomato variety	**Reason**

23. Are you aware of the new varieties being tested by CABI for controlling nematodes? Yes/No --

If yes how do you rate them compared to the varieties that you are using currently?

Technology	**Rate (tick one)**			
	Better	**Same**	**Worse**	**Don't know**
Nemonetta				
Monyala				
Cal-J				
Caltana				

Give reasons why you think they should be rated as such: --------------------------------
Nemonetta (*reasons*) --

Monyala (*reasons*) --

Cal-J (*reasons*) --

Caltana (*reasons*) ---

----

24. Are there any problems with these new varieties? ---

----

25. Do you envisage any increases in production due to the new/ improved varieties? Yes/No/Don't know ---

26. Are you likely to try any of the varieties on your farm?
Please give reasons against each one

Technology	**Yes**	**No**	**Don't know**	**Reason**
Nemonetta				
Monyala				
Cal-J				
Caltana				

27. Please provide suggestions for improving the new varieties being tested ----------
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SECTION F: BIOLOGICAL CONTROL AGENTS (BCAs) /ROTATION

28. Are you aware of the BCAs /rotations being promoted by CABI for controlling nematodes? Yes/No ---------------

If yes how do you rate them compared to the methods (tomato without BCA) that you are using currently?

Technology	Rate (tick one)			
	Better	Same	Worse	Don't know
Tomato with BCAs				

Give reasons why you think they should be rated as such: --------------------------------
----

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29. Do you envisage any increases in production due to the BCAs /rotations? Yes/No/Don't know --

30. Are you likely to try using the BCAs /rotations on your farm? (yes/no/don't know) ---

Please give reasons for your answer (identify likes & dislikes of BCAs)

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31. Please provide suggestions for improving the BCAs /rotation

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