CROP PROTECTION PROGRAMME AND LIVESTOCK PRODUCTION PROGRAMME

"Evaluation of the effects of plant diseases on yield and nutritive value of crop residues used for peri-urban dairy production on the Deccan Plateau"

R 7346(ZA0286)

FINAL TECHNICAL REPORT

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Executive Summary

A very brief summary of the purpose of the project, the research activities, the outputs of the project, and the contribution of the project towards DFID's development goals. (Up to 500 words).

Increased milk production in India will require higher quality crop residues. On the Deccan Plateau, sorghum and groundnut provide most residues. However, these crops are susceptible to diseases. The present project was initiated with the objectives of assessing the impact of diseases on the quantity/quality of crop residues, and developing methods to eliminate deleterious effects. Surveys of disease incidence and effects on the purchasing price of residues were conducted. The influence of management practices on disease incidence was also studied and trials were undertaken with ruminants to measure the intake and digestibility of crop residues.

In four groundnut genotypes tested, the two major foliar diseases, late leaf spot and rust reduced the pod/ haulm yields by 70% and the *in vitro* digestibility of haulms by 22%. Two genotypes (ICGV 92020 and 92093) were highly resistant to these foliar diseases maintaining high pod and haulm yield as well as high *in vitro* digestibility of haulms (>62.3%) even under the highest disease pressure.

Important diseases in sorghum were maize stripe virus (MStV) and anthracnose (*Colletotrichum graminicola*). MStV reduced grain yield by 30%, stover yield by 42% and digestible stover yield by 45%. Effects of MStV were highly genotype-dependent, and grain and stover yields were affected in different ways in different varieties. Anthracnose reduced grain yield by 47% and stover yield by 23%, but effects on stover quality were variable. As observed for MStV, the effects of anthracnose were highly genotype-dependent. Genotypes were identified that maintained high grain and stover yields under significant disease pressures.

The use of resistant genotypes and/or disease management with fungicides improved the crop residue yields, as well as the nutritive value of groundnut and sorghum fodder, by >70%.

Background

Information should include a description of the importance of the researchable constraint(s) that the project sought to address and a summary of any significant research previously carried out. Also, some reference to how the demand for the project was identified.

India has the largest population of ruminants in South Asia, and livestock production forms an integral part of an age-old system of mixed farming. However, in recent times, specialised peri-urban dairy farming has been developed by the landless in many areas. The predicted `livestock revolution' will provide opportunities for enhancing milk production to meet the requirements of an increasing human population and for improved livelihoods, provided that constraints can be overcome. One of the most important technical constraints to animal production is the inadequate supply of high quality feed resources throughout the year. As the area of common property resources for grazing continues to decline with increased cultivation, the dependence on crop residues and agro-industrial by-products as feed resources will continue to increase.

The principal crop residues used as fodder are those from cereals followed by those from pulses. On the Deccan Plateau, in Andhra Pradesh, sorghum and groundnuts are the major sources of crop residues for livestock. Sales of cereal crop residues to peri-urban producers account >50% of the income derived from cropping in rural areas. Large areas of dual-purpose cultivars of sorghum and groundnut are grown on the Deccan Plateau. These cultivars, providing both grain and straw for animal feed, are very important to farmers who care as much about fodder yields as they do about grain yields. The increasing importance of sorghum straw is reflected in its market price, which in parts of India has been increasing relative to the price of grain. Groundnuts are also an important oilseed crop in Andhra Pradesh, accounting for 21% of the total production in India. Groundnut crop residues are highly nutritious and are exchanged for food and feed (for example rice straw and sorghum stalks), and are traded locally within the villages or communities. Groundnut haulms are fed preferentially to lactating cows and buffalo. Although crop residues are a major roughage source for dairy animals in India, their nutritive value is low. If ruminant productivity is to be increased to meet new demands for milk, then the availability of higher quality crop residues will be a critical factor. Improving the yield and feeding value of crop residues will increase the availability of nutrients to ruminants, help alleviate animal feed deficits and enhance the benefits resulting from the complementarities between crop and livestock systems.

Project Purpose

The purpose of the project and how it addressed the identified development opportunity or identified constraint to development.

It was against the above background and rationale that the current project (*ZA0287/ R7346)* was conceived. Traditional dual-purpose sorghum cultivars are susceptible to foliar and stalk diseases, whilst commonly-grown groundnut cultivars are susceptible to foliar diseases. The quantity and nutritive value of their residues are also likely to be affected by these diseases, as well as grain yields. In many ways the project is unique. It has been funded by two DFID research programmes; one (the Crop Protection Programme) does not have a history of involvement in livestock-related work. Plant, animal and social scientists have participated in the various studies in a truly multi-disciplinary manner. The research is novel. The effects of pathogenic micro-organisms on grain yields are well documented, but effects on biomass yield and nutritive value are rarely recorded. Activities have involved not only *in vitro* studies of nutritive value in the laboratory, but also *in vivo* assessment in both buffalo and cattle. In addition to two international agricultural research centres, the work has involved the NARS and NGOs and provided a training opportunity for postgraduate students.

Research Activities

This section should include detailed descriptions of all the research activities (research studies, surveys etc.) conducted to achieve the outputs of the project. Information on any facilities, expertise and special resources used to implement the project should also be included. Indicate any modification to the proposed research activities, and whether planned inputs were achieved.

The following proposed research activities were conducted under this project without any modifications:

1. Participatory rural appraisal (PRA) studies

These studies were carried out, between August and October 1999, in four villages in two districts of Andhra Pradesh on the Deccan Plateau. The aim was to understand the effects of foliar diseases on yield and nutritive value of sorghum and groundnut residues, as perceived by male and female farmers. Two villages were chosen for each for sorghum- and groundnut-based cropping system to represent two different situations with regard to the importance of livestock, linkages with fodder markets and the intensity of dairy activities. The studies were targeted to understand (a) feeding systems and fodder-use patterns (b) preferential feeding (c) relative importance of sorghum and groundnut crop residues (d) perceptions of farmers on the quality of sorghum/groundnut crop residues (e) perceptions on the incidence of pests/diseases (f) the perceptions of farmers on relevance and importance of foliar diseases/pests (g) effects of foliar diseases on fodder price and (h) gender perceptions.

2. On-station evaluation of effects of foliar diseases on the yield groundnut and sorghum crop residues

2.1 Groundnut: The effects of foliar diseases - late leaf spot and rust on the haulm and pod yields of four genotypes of groundnut, ICGV 91114 (early-maturing in 95 days), ICGV 92020, ICGV 92093 (medium-maturing in 125 days) and TMV 2 (similar to the local cultivar used by farmers, matureing in 110 days) were studied. The experiments were conducted at the ICRISAT with three replications arranged in a split-plot design. The experimental plots were artificially inoculated with *P. personata* and *P. arachidis.* Three disease levels were maintained by adopting intensive management (IM), moderate management (MM) and no management (NM) for both late leaf spot and rust. In the IM practice, the fungicide Kavach® (chlorothalonil) was applied as a foliar spray at 10-day intervals from 30 days after sowing to maturity. In the MM practice, Kavach was applied as a foliar spray at 60, 75 and 90 days after sowing. In the NM practice, the fungicide was not applied throughout the crop season.

The severity of foliar diseases (both late leaf spot and rust) was scored at 10-day intervals from 45 days after sowing until maturity on a modified 1-9 rating scale, where 1 = no disease and 9 = maximum disease i.e., almost complete defoliation (Subrahmanyam et al., 1995). At maturity, the crop in all plots was harvested by uprooting all plants. Pods were handpicked and both pods and haulm were sun dried. After complete drying, haulm and pod weights were recorded to calculate the yield per hectare. For haulm quality analysis at maturity, about 20 plants from each plot were cut at the collar region. After harvesting and hand picking of pods, haulms were oven dried at 50°C until they attained a constant weight, and ground to pass through a 1 mm particle size sieve.

2.2 Sorghum: The effects of maize stripe viral disease (MStV) and anthracnose on the fodder quality of sorghum were evaluated. Three genotypes of sorghum, M 35-1, ICSV 93046 and ICSV 745 were used to study the effect of MStV, and artificial inoculation was carried out using adult plant hoppers as vectors at 20 days after sowing. The number of diseased plants was counted at 7-day intervals up to harvest, to determine progress of the disease in each plot. At physiological maturity, leaves, stems and panicles of all plants were collected from the central four rows of each plot. The leaves and stems were dried at 50^{O} C until they achieved a constant weight, ground and then used for laboratory analysis. Panicles were threshed from each plot and the grains were sun dried. Dry weights of the grains were recorded and yields per hectare were calculated.

Five genotypes, Bulk Y, H 112, IS 3089, Local FSRP and Yellow Jowar were used to study the effects of anthracnose on the sorghum fodder quality. The experiment consisted of six treatments (a) minimum disease – no inoculation and intensive spraying of the fungicide Dithane M-45 @ 0.2% (b) maximum disease –inoculation and no fungicide application (c) low disease – inoculation and subsequent strategic fungicide application to maintain disease severity at a low level (d) moderate disease – inoculation and subsequent strategic fungicide application to maintain disease severity at moderately high level (e) high disease – inoculation and subsequent strategic fungicide application to maintain disease severity at a high level and (f) control – no inoculation and no fungicide application. For artificial inoculation, *C. graminicola* was multiplied on sterilised sorghum grains in the laboratory, and 3-4 colonised sorghum grains were placed in the whorl of each plant 30 days after planting (Pande et al., 1994). After inoculation, sprinkler irrigation was provided daily for one week to provide moisture for fungal multiplication and to induce infection and disease development. In each treatment five plants with uniform growth were tagged and scored on a 0-100% severity scale (% leaf area damaged by anthracnose) at 7-day intervals starting from 10 days after inoculation to maturity. For descriptive stover quality assessments, severity of external (after removing all the floral parts) and internal stem discoloration (after splitting open the stem with a knife) were rated on a 1-9 scale (1 = no discoloration either externally or internally; 9 = >75% discoloration either externally or internally). At physiological maturity, ten plants in each treatment were cut at the 2^{nd} node. Stems and leaves were separated and dried at 50^{O} C until they reached constant weight, and then ground for laboratory analysis.

2.3. Laboratory analysis of fodder value of groundnut haulm and sorghum stover: For quality analysis, air-dried samples were ground through a 1-mm mesh. Nitrogen (N) was determined using a Technicon Auto Analyser on air-dry feed material and was corrected for dry matter (DM). Dry matter and ash were determined according to the AOAC (1980). Neutral detergent fibre (NDF) was determined by the method of Van Soest and Robertson (1985), and sugar content in feed was analysed by the colorimetric method of Dubois et al. (1956).

Rumen inoculum for the *in vitro* incubations was obtained from two rumen-cannulated steers (local Indian breed) kept on a diet of crop residues. A mixture of rumen fluid and particulate matter (approximately 60: 40) was collected in CO_2-filled thermos bottles, transferred to and homogenised in a household blender, and strained and filtered through glass wool. All handling of rumen inoculum was carried out under continuous flushing with CO_2. Portions of a 200 mg air dry sample were accurately weighed (in triplicates) into 100 ml calibrated glass syringes, fitted with plungers as described by Menke et al. (1979), but modified as described by Blümmel and Ørskov (1993). A total of 30 ml of medium consisting of 10 ml of rumen inoculum and 20 ml of an ammonium and sodium bicarbonate/mineral-distilled water mixture was injected into the syringes. Three blanks containing 30 ml of medium only were included at the beginning and at the end of the incubation period. Accumulating gas volumes were recorded after 24 and 48 hours of incubation. *In vitro* digestibility was calculated as 15.38 + (0.8453* ml of gas produced after 24 h) + (0.595* % crude protein) + (0.181* % ash) as described by Menke and Steingass (1988).

Outputs
The research results and products achieved by the project. Were all the anticipated outputs achieved and if not what were the reasons? Research results should be presented as table, graphs or sketches rather than lengthy writing, and provided in as quantitative a form as far as is possible.

Output 1: *Improved understanding of the incidence and severity of foliage and stalk diseases of sorghum and groundnut residues destined for animal feed.*

Achievements: On-farm surveys of 585 sorghum and groundnut fields were conducted three times during the growing season to monitor diseases. In sorghum, maize stripe virus, anthracnose, oval leaf spot, zonate leaf spot and rust were the most important foliar diseases. In groundnuts, early leaf spot, late leaf spot and rust caused severe defoliation and reduced the yield of crop residues by > 50%. Bud necrosis (4-35% incidence) was severe in Andhra Pradesh. Stem rot was also important in the same state and in Karnataka state (4-25% incidence). PRA studies concluded that foliar diseases affected health and milk yields when diseased residues were fed to ruminants.
The fodder market surveys indicated that plant diseases were one of the most important determinants of the sale price for sorghum.

Output 2: *Quantification of the effects of diseases on vegetative yield and in vitro nutritive value of traditional and new varieties of sorghum and groundnut.*

Achievements: In the on-station trials, foliar diseases of sorghum and groundnuts substantially reduced yields and nutritive value of the residues.

1. Groundnut

1.1 Effect of foliar diseases on the haulm yield of groundnut: Significant differences ($P < 0.05$) in haulm yields were recorded between management practices and genotypes. Higher haulm yields were obtained under the intensive management practice. Under all management practices, the highest and lowest haulm yields were recorded in cultivars ICGV 92093 and TMV 2, respectively. Under the no-management practice, foliar diseases severely reduced haulm yields of ICGV 91114 and TMV 2. The haulm yield of ICGV 91114 and TMV 2 was increased by 40% and 47% by moderate management and 67% and 115%, respectively, by intensive management of the foliar diseases. Genotypes ICGV 92020 and ICGV 92093 retained much of their foliage under the no-management practice yielding 2.82 and 2.90 t ha^{-1} haulms, respectively. The yields of these two genotypes were significantly higher than the yields of ICGV 91114 and TMV 2 under the intensive management practice.

1.2 Effect of genotype and foliar diseases on the fodder value of groundnut haulms: Significant differences ($P<0.05$) in protein content were observed between genotypes but not between management practices. The highest protein content was recorded in genotype ICGV 92093. Under low disease pressure, *in vitro* digestibilities were similar amongst all genotypes. Foliar diseases significantly decreased *in vitro* digestibililties but genotypes were affected differently. Whilst decreases in *in vitro* digestibilities were comparatively small in ICGV 92093 and 92020, substantial (>10%) reductions were observed for TMV 2 and ICGV 91114.

1.3 Relationship between fodder quality of groundnut haulms and pod/haulm yields: *In vitro* digestibility of haulms was positively associated ($P < 0.0001$) with yield of haulms.

2. Sorghum

2.1 Incidence of MStV and its effect on grain yield and total and digestible stover yield: Significant differences ($P < 0.05$) in the mean cumulative incidence of MStV were observed between genotypes. Mean cumulative incidence was 38% in ICSV 93046, 26% in M 35-1 and 18% in ICSV 745. MStV severity was higher in the initial four weeks than in later weeks, indicating that the vegetative growth stage of sorghum was more susceptible to MStV than the reproductive growth stage.

MStV significantly depressed both stover and grain yield, but depressions were genotype dependent. Not surprisingly, reductions in digestible yield of healthy stover relative to the control were highest in lCSV 93046; the genotype with the highest disease incidence in inoculated plots. Within disease-affected stover, reductions in digestible stover yield were greatest in ICSV 745. Symptomless plants in the control treatment had higher digestible straw yields than those plants in the inoculated treatment for all genotypes.

2.2. Incidence of anthracnose and its effects on grain and stover yield, *in vitro* gas production and sugar and cell wall (NDF) content of stover: In the trial, Bulk Y and IS 3089 were damaged by birds and downy mildew, so were not recorded. Fungicide application maintained a minimum disease level of anthracnose of < 3% in all genotypes. Without fungicide, susceptibility to anthracnose was highly genotype-dependent under all levels of anthracnose severity. In general, H112 had the highest disease level followed by Local FSRP and Yellow Jowar.

The effects of anthracnose on grain and stover yield of the remaining three genotypes were variable. In Yellow Jowar, treatments with low disease levels (low disease and natural treatments) had significantly more grain yield compared to treatments with very low (minimum disease) or very high disease levels (maximum and high disease treatments). The stover yield of Yellow Jowar was significantly lower under maximum and natural disease regimes compared to minimum disease. Grain and stover yields of H 112 in all the treatments without fungicide protection were significantly lower than the minimum disease treatment. In Local FSRP, the maximum disease treatment had a lower grain yield than the minimum disease treatment, but stover yields were statistically similar in all treatments.

Significant genotype-dependent differences were found in *in vitro* gas production, sugar and cell wall (NDF) contents of the genotypes.these laboratory quality indicators. *In vitro* gas production was lower in stems than in leaves, whilst sugar and NDF contents were higher in stems than in leaves. *In vitro* digestibility was significantly lower in the maximum disease treatment compared to the minimum disease treatment. In general, however, anthracnose had very little effect on laboratory quality indicators, and differences between measurements under minimum and maximum disease level were small. Similarly, quality indictor means across genotypes and disease levels were very similar to those observed in healthy sorghum.

***Output 3**: Increased awareness by farmers and fodder traders of the effects of plant diseases on the purchasing price of crop residues.*

Achievements: The fodder market surveys indicated that plant disease was one of the most important determinants of the sale price for sorghum residues. PRA studies concluded that foliar diseases of groundnut affected animal health and milk yields when diseased residues were fed to ruminants.

In general, animals refuse to eat diseased crop residues of groundnut and sorghum and often suffer from indigestion and diarrhoea.

Output 4*: Improved knowledge of the effects of management practices on the incidence of diseases in crop residues.*

Achievements: In the on-station trials, sorghum genotypes had a stronger effect than fertility levels for managing foliar anthracnose to increase grain/residue yields. Resistant cultivars and two sprayings of fungicides on local cultivars (susceptible to foliar diseases) of groundnut commonly grown by farmers reduced foliar diseases, and increased haulm/pod yields by more than 3.5 times compared to the control. Several farmers were provided with the seed of resistant cultivars and/or recommendations on disease management practices to combat foliar diseases in groundnut and improve haulm and pod yields.

Output5: *Improved understanding of the effects of plant diseases on the utilisation of crop residues by large ruminants.*

Achievements: More than 1.5t each of healthy and diseased sorghum stover and groundnut haulm were produced for the *in vivo* animal feeding trials. Studies on the effect of foliar diseases of groundnut on intake and digestibility in cattle and buffalo concluded that the dry matter intake (DMI as a % of live weight) of healthy groundnut haulms was 2.6% in comparison to 1.8 % for diseased haulms. Similarly, dry matter digestibility (DMD) of healthy haulms was 8% higher than the DMD of diseased haulms. Also, groundnut haulms obtained from disease-resistant genotypes (such as ICGV 92020, ICGV 92093), that were grown under high disease pressure, showed more than 11% *in vitro* digestibility. There was a positive correlation between *in vitro* digestibility and pod and haulm yield in groundnut. This clearly suggests that groundnut genotypes with higher pod and haulm yield, and better resistance to foliar diseases than susceptible genotypes, will be preferred by poor peri-urban dairy farmers.

Output 6: *A bulletin on the evaluation and management of important foliar and stalk diseases of sorghum and groundnut residues. Preparation of research papers and extension material.*

Achievements: Several conference papers and journal articles have been prepared and some of them are already published. An information bulletin on the evaluation and management of important foliar diseases of sorghum and groundnut is in preparation. The published research articles are:

- Pande, S., Bandyopadhyay, R., Blummel, M., Rao, J.N., Thomas, D. and Navi, S.S. 2003. Disease management factors influencing yield and quality of sorghum and groundnut crop residues. *Field Crops Research* (in press).

- Kishore, G.K., Pande, S., Manjula, K., Rao, J.N. and Thomas, D. 2002. Occurrence of mycotoxins and toxigenic fungi in groundnut (*Arachis hypogaea*) seeds in Andhra Pradesh in India. *The Plant Pathology Journal*. 18:204-209.
- Pande, S. and Rao, J.N. 2002. Effect of plant population densities on the severity of late leaf spot and rust of groundnut. *The Plant Pathology Journal*. 18: 271-278.
- Pande, S. and Rao, J.N. 2002. Components of resistance to late leaf spot caused by *Phaeoisariopsis personata* in interspecific derivatives of groundnut. *Indian Phytopathology*. 55:445-450.
- Pande, S. and Rao, J.N. 2000. Changing scenario of groundnut diseases in Andhra Pradesh, Karnataka and Tamil Nadu states of India. *International Arachis Newsletter*. 20:42-44.
- Dwiwedi, S.L., Pande, S. and Rao, J.N. 2002. Components of resistance to late leaf spot and rust among interspecific derivatives and their significance in a foliar disease resistance breeding in groundnut (*Arachis hypogaea* L.). *Euphytica*. 125:81-88.
- Kishore, G.K., Pande, S. and Rao, J.N. 2001. Control of late leaf spot of groundnut (*Arachis hypogaea*) by extracts from non-host plant species. *The Plant Pathology Journal*. 17:264-270.
- Rama Devi, K., Bandyopadhyay, R., Hall, A.J., Indira, S., Pande, S. and Jaiswal, P. 2000. Farmers' perceptions of the effects of plant diseases on the yield and nutritive value of crop residues used for peri-urban dairy production on the Deccan Plateau: Findings from participatory rural appraisals. *Information Bulletin No. 60*. ICRISAT, Patancheru 502 324, Andhra Pradesh, India

Contribution of Outputs to developmental impact

Include how the outputs will contribute towards DFID's developmental goals. The identified promotion pathways to target institutions and beneficiaries. What follow up action/research is necessary to promote the findings of the work to achieve their development benefit? This should include a list of publications, plans for further dissemination, as appropriate. For projects aimed at developing a device, material or process specify:

Improved methods for control of diseases and pests of sorghum and groundnut crop residues in intensive dairy production units have been developed and are ready to promote. The project has assessed the importance of plant diseases on the yield and nutritive value of sorghum and groundnut residues, and modified existing on-farm management practices to control diseases/pests beyond the grain harvest period to benefit the quality of crop residues used for dairy production.

a. What further market studies need to be done?

Adequate market studies were conducted in Phase 1 on the suitability of healthy crop residues for peri-urban dairy production. During the surveys, it was found that healthy crop residues command higher prices than diseased crop residues. However, if the project is extended, market studies on the procurement system for crop residues will be necessary.

b. How the outputs will be made available to intended users?

In the final stakeholder workshop, resource-poor farmers growing and selling crop residues to peri-urban dairies, fodder traders, scientists and personnel from the NGOs all expressed their appreciation of the project, and emphasised the need to scale-up the multiplication of seed of new dual-purpose sorghum and groundnut varieties. Farmer to farmer seed exchange is being established through self-help groups at community level.

c. What further stages will be needed to develop, test and establish manufacture of a product?

There are two main products from Phase 1, (a) the availability of disease/pest-resistant sorghum and groundnut varieties and (b) disease/pest management technologies. These two products need to be further promoted at village level.

d. How and by whom, will the further stages be carried out and paid for?

In Phase 1, a mechanism for seed multiplication and distribution of pest/disease-resistant, dual-purpose varieties at community level has been established, and will be carried through by self-help groups and NGOs. Where NGOs are not active, the process will be undertaken by Government agencies such as the Departments of Agriculture and Extension. Hopefully, funding for a Phase 2 of the project will initiate this process.

Biometricians Signature

The projects named biometrician must sign off the Final Technical Report before it is submitted to CPP. This can either be done by the projects named biometrician signing in the space provided below, or by a letter or email from the named biometrician accompanying the Final Technical Report submitted to CPP. (Please note that NR International reserves the right to retain the final quarter's payment pending NR International's receipt and approval of the Final Technical Report, duly signed by the project's biometrician)

I confirm that the biometric issues have been adequately addressed in the Final Technical Report:

Signature:
Name (typed): Mr Ravi Devulapalli
Position:
Date:

"This publication is an output from a research project funded by the United Kingdom Department for International Development for the benefit of developing countries. The views expressed are not necessarily those of DFID." *[R7346 The Crop Protection Research Programme]*