CROP PROTECTION 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 8339 (ZA 0598)

FINAL TECHNICAL REPORT

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Project Leader : P.Parthasarathy Rao

ICIRSAT, Patancheru 502 324, Andhra Pradesh, India

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Submission requirements:

The Final Technical Report must be submitted to CPP on the contractual date the project ends. A letter of reminder specifying number of copies, and any other relevant details, will be sent to project leaders close to the project's end date.

FINAL TECHNICAL REPORT

Executive Summary

Increased milk production in India will require improved yields of higher quality crop residues. On the Deccan Plateau in the state of Andhra Pradesh, traditional dual-purpose sorghum and groundnut crops provide most of the residues. Although crop residues are a major roughage source for ruminants, nutritive value is often low. Furthermore, sorghum and groundnut are susceptible to a number of foliar and stalk diseases that may reduce production and quality. The effects of pathogenic fungi on grain/pod yields are well documented in the literature, but effects on the yield and nutritive value of stover/haulms are rarely recorded. Another concern is the production of mycotoxins on crop residues that present a serious threat to animal health and, through milk, to human health. In the first stage of the project (R. 7346), the effects of plant diseases on yields and nutritive value of crop residues used for peri-urban/urban dairy production were evaluated. Results showed that two major fungal diseases (late leaf spot and rust) in groundnut reduced pod/haulm yields by 70% and *in vitro* digestibility of haulm by 22%. In sorghum, two major diseases (anthracnose and maize stripe virus) reduced grain yields by 30-47% and stover yields by 23-42%. The integrated use of resistant genotypes, and disease management with fungicides, improved stover/haulm yields and nutritive value in both crops by >70%. Accordingly, Project R. 8339, an extension of R. 7346, has been concerned, *inter alia*, with the dissemination of integrated disease-management technology based on superior, resistant, dual-purpose groundnut cultivars to farmers in the major production area of Ananthapur district. The project has been linked intimately with project R. 8298 (an extension to R. 7809), concerned with the dissemination of technologies at farm level to reduce mycotoxin contamination.

If new cultivars are to be adopted successfully by farmers, then access to high quality seed is essential. For sorghum, the private sector can serve as a seed multiplier. On the other hand, to achieve wide dissemination of groundnut seed, village-based systems of multiplication/distribution based on self-help groups of farmers with NGO participation need to be established. Farmers involved in the project were provided with training on improved crop/disease management technologies. Concurrently, on-farm measurements supported by laboratory analyses at the ICRISAT-ILRI were undertaken to define the availability of feed resources, assess the effects of plant diseases on groundnut production and, hence, milk yield. Economic advantages of growing the new cultivars over traditional varieties were measured from primary data collected from surveys in the project area.

Village-level, farmer-participatory seed multiplication/duplication schemes, based on self-help groups, were established successfully to provide quality seed of the new disease-resistant, dual-purpose groundnut cultivars, as part of the pro-poor integrated disease management strategy. Some 214 farmers from 12 villages have participated in wet season and post-wet season seed activities in Ananthapur district. Farmers have contributed to village seed banks by returning twice the quantity given to them for planting. Farmers identified the new cultivar ICGV-91114 as outstanding for both grain and haulm production and quality. The area under new cultivars is now some 3,000 hectares. At current rates of adoption, it is estimated that by 2007 the area under improved cultivars will be 30,400 hectares and, by 2010-2011, some 80,000 hectares, with dissemination from Andhra Pradesh into the neighbouring states of Karnataka and Tamil

Nadu. Nearly 300 farmers took part in an orientation programme on farmer participatory disease management in dual-purpose groundnuts in 2004 and a stakeholder workshop in 2005.

Surveys of sample farmers in the project villages indicate that groundnut accounts for 61-75% of the cropped area under rain-fed and irrigated conditions. Groundnut haulms provide >50% of dry fodder, and >25% of haulm is exchanged in the village. Also, the farmers are purchasing 75% of paddy rice straw from 100-150 km away, and 50% of sorghum straw from nearby villages. Compared to traditional varieties, ICGV-91114 is more resistant to diseases and drought. Mean pod yields are 15% higher than those of local varieties, and mean haulm yields are 17% higher. Laboratory analyses of on-farm groundnut haulms confirm that nutritive value of improved cultivars is high. The ranges for crude protein content, *in vitro* digestibility and metabolizable energy are 13.9-15.8%, 63.2-65.3% and 8.8-9.2 MJ/kg, respectively.

On-farm milk production trials showed close to 50% of the milk samples to have non-permissible aflatoxin content (> 0.5 μg/kg). Aflatoxin content of haulms was low suggesting that recommendation of removing residual small pods – hot spots for the fungi – form the haulms were largely accepted. In general aflatoxin content of feed refusals was higher than in feed offered, and re-feeding of refusals should be discouraged. A fodder source with high aflatoxin content was groundnut cake (>98 μg/kg).

Laboratory measurements of nutritive value have been related to animal performance data using simple and multiple regression analyses. Laboratory measurements that predict animal performance accurately have been used for the development of near infra-red spectroscopy equations to provide a rapid and non-destructive analytical tool for estimating crop residue feeding value.

Economic analyses have shown that gross returns on farm are much higher for ICGV-91114 than for traditional groundnut varieties. Although cultivation costs are higher, the overall per unit costs of production for ICGV-91114 were 9% lower under irrigation and 8% lower under rain-fed conditions. Net returns from the growing of ICGV-91114 were about 29% higher under irrigation and 25% higher under rain-fed conditions. Across cultivars, seed is the most expensive input accounting for 36-42% of total costs. Currently, farmers are receiving Rs. 24-28/kg for seed of ICGV-91114 compared to Rs. 18-22/kg for seed of traditional varieties. Milk yields per animal on farm are 0.4-0.5 litres/day higher with ICGV-91114 than those with the local varieties. Some 70-80% of milk is sold through both formal and informal channels, and income from sales ranges from 15-25% at the household level. The advantage from growing improved cultivars is therefore threefold: 1) higher pod yields, 2) higher haulm yields and 3) higher milk yields from dairy animals fed the haulms. Returns have been assessed at varying adoption rates of improved cultivars.

Background

India has the largest population of ruminants in South Asia, and livestock production is an integral part of mixed farming systems. However, in recent times, specialised peri-urban/urban dairy production has been developed by the landless in many areas. The so-called "livestock revolution" will provide opportunities for increased production of milk to meet the requirements of the increasing human population and lead to 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, so the dependence on crop residues (mainly cereals and pulses) and agro-industrial by-products will increase in importance.

On the Deccan Plateau, in Andhra Pradesh state, dual-purpose sorghum and groundnut are the major sources of grain and of crop residues for ruminant livestock. Sales of cereal crop residues

to peri-urban/urban milk producers' account for large share of the income derived from cropping in rural areas. The increasing importance of sorghum stover for animal feed is reflected in its market price, which has been increasing relative to the price of grain in recent times. Recent surveys by the project in fodder markets indicate that stover/grain ratios in sorghum have fallen to as low as 1:2, as a result of shortages of fodder. Depending on stover quality, farmers are getting more income from the sale of crop residues. Groundnuts are also an important crop in Andhra Pradesh, accounting for some 21% of the total production in India. Groundnut residues can be nutritious for livestock, and are used locally either by farmers themselves or exchanged for food and other crop residues. In Ananthapur district, groundnut accounts for 61-77% of the cropped area under irrigation and rain-fed conditions.

If ruminant productivity is to be raised to meet new demands for milk, then the availability of crop residues of good quality must be increased. Improving the yield and nutritive 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 crops and livestock in mixed farming systems. In the past, plant breeders have concentrated only on the improvement of grain yields for human nutrition. There is now greater awareness of the need to breed dual-purpose cultivars, with emphasis on the improvement of both grain and fodder yields/quality to meet the demands of farmers. Project R. 8339 and its first phase, Project R. 7346, are linked intimately to a major ICRISAT-ILRI breeding initiative aimed at the genetic enhancement of grain/pod production and nutritive value in the stover/haulm of sorghum, pearl millet and groundnut.

Traditional dual-purpose sorghum cultivars are attacked by foliar and stalk diseases, whilst the local groundnut cultivars are susceptible to foliar diseases. The effects of pathogenic fungi, bacteria and viruses on grain yields are well documented in the literature, but effects on vegetative yields and nutritive value of the straw/haulm are rarely recorded. Of further concern is the production by saprophytic fungi (species of *Aspergillus*, *Fusarium* and *Penicillium*) of secondary metabolites called mycotoxins (including aflatoxins and fumonisins) on crop residues, which present a serious threat to the health of animals and, through contaminated milk, to human health. Animal feeds such as cereal grains and oilseed cakes are also known to be sources of mycotoxins. Aflatoxins are produced by *Aspergillus flavus*, and are the major mycotoxins contaminating groundnuts. A major pathway for mycotoxins into the human food chain is through milk. The findings of a related DFID-supported project (R. 7809 - *Strategies for Reducing Aflatoxin Levels in Groundnut-based Foods and Feeds in India: A Step Towards Improving Health of Humans and Livestock*) show that resistance to foliar diseases in groundnut is related positively to aflatoxin resistance. Dissemination of genotypes resistant to foliar diseases could contribute to reduced mycotoxin contamination.

Accordingly, Project R. 7346 evaluated the effects of plant diseases on yields and nutritive value of crop residues used for peri-urban/urban dairy production on the Deccan Plateau. Results showed that two major foliar diseases in groundnut, late leaf spot and rust, reduced pod/haulm yield by 70% and *in vitro* digestibility of haulm by 22%. Genotypes highly resistant to these foliar diseases were identified with high pod/haulm yields and *in vitro* digestibilities in the haulm of >62%, even under high disease pressures. In sorghum the two most important diseases were maize stripe virus (MStV) and anthracnose (*Colletotrichum graminicola*). MStV reduced grain yield by 30% and stover yield by 42%. The effects of MStV were highly dependent on genotype. Anthracnose reduced grain yield by 47% and stover yield by 23%. The effects on the nutritive value of the stover were highly variable. Again, the effects of anthracnose were highly dependent upon genotype. The integrated use of resistant genotypes and disease management with fungicides improved stover/haulm yield and nutritive value in both crops by >70%. Project R. 8339 has been concerned, *inter alia*, with the dissemination of disease-resistant, dual-purpose cultivars of groundnut to farmers in the major production area of Ananthapur district. It has been linked intimately with project R. 8298 (an extension of R. 7809) that has been

concerned with the dissemination of technologies to reduce mycotoxin contamination at farm level.

Table 1 compares indicators for Ananthapur district with those for the state of Andhra Pradesh as a whole. It is clear that rural poverty is higher than the state average. With the exception of size of holdings, all other indicators for Ananthapur district are lower than those for Andhra Pradesh. Of particular note for the project is:

- Annual rainfall is 56% of the state average, but the area under irrigation is low.
- The area under high yielding cultivars is very low.
- Fertiliser use is one quarter that of the state average.
- The proportion of crossbred dairy cattle is about half that of the state average.

This district is the largest groundnut-growing area in the world. In the 2004 wet season, 0.85 million hectares were sown to groundnut under rain-fed conditions. Seed requirements were 0.11 million tonnes. However, some 90% of the area remains under traditional varieties (TMV-2, JL-24, Pollachi Red) that are 40-60 years old. Some 70% of seed is of TMV-2, 10% JL-24 and 10% Pollachi Red. Limited access to good quality seed of new, improved groundnut cultivars is one of the major factors contributing to low farm yields. Due to a high seed rate (100-150 kg/ha) and a relatively large seed size, the seed requirement for groundnut is huge. In rain-fed agriculture, the seed problem is further accentuated by drought and shortages in supply increase prices significantly.

In countries such as India, where 7.0 million hectares of groundnut are grown, no single agency can meet the demands for seed. For example, the Government of Andhra Pradesh meets only 30% of the seed demand at a subsidised rate in Ananthapur district, through its seed-producing agencies and from purchase through open tenders. Small farmers (farms of <2.0 ha) procure the remainder from various sources e.g. large farmers (farms of >4.0 ha), unscrupulous middlemen, friends/relatives or local markets. There is little control of seed quality. The post-wet season crop in the district supplies 40% of the seed requirement. Some 20% of the area is irrigated. The remainder comes from other districts (Mahabubnagar, Cuddapah, Kurnool and Chittor). There is very little formal seed production in the district. Accordingly, village-based seed multiplication/distribution schemes were established to overcome these constraints and contribute to the sustainability of seed supply of the new cultivars.

Table 1. Selected indicators for Ananthapur and Andhra Pradesh 2001.

Indicators	Ananthapur	Andhra Pradesh
Demographic		
Population density (No./sq.km)	190	276
Urban population (%)	25	27
Literate rural female (%)	33	39
Rural poverty (%)	39.1	27.4

Agrarian structure/farm size		
Average size of land holding (ha)	2.5	1.4
No of small land-holders (%)	59	81
Technological		
Irrigated area (% to gross cropped area)	16	42
Area under high yielding varieties (%)	5	33
Fertilizer (kg/ha of net cropped area)	48	193
Tractor density (per 000 ha of NCA)	3.8	8.7
Cropping intensity	104	142
Agro-climatic		
Average normal rainfall (mm)	497	881
Infrastructure		
Road density (km/sq.km of geog.area)	0.5	0.6
Market density (markets/10,000 sq.km of geog.area)	25	27
Livestock		
Common property resources (% to geog.area)	14	19
Feed availability (t/LSU)	1.3	1.6
Improved poultry (%)	18	56
Crossbred cattle (%)	3.81	7.09
Crossbred sheep (%)	0.28	0.77
Adult female bovine to male bovine (ratio)	1.09	1.45
Socio-economic		
All crop and livestock value (Rs/ha of GCA)	3205	7003
Credit (Rs./ha)		
Crop	4156	7818
Agricultural allied activities	179	769

Project Purpose

Project R. 8339 is a logical sequel to Project R. 7346, and contributes to the CPP purpose of *"developing pro-poor strategies to reduce the impact of key pests, improve yield and quality of crops, and reduce pesticide hazards in peri-urban systems."* A major output from the earlier project was the identification of disease-resistant, dual-purpose cultivars capable of producing high yields of grain and nutritious stover/haulm, as part of an integrated disease management strategy. In a stakeholder meeting at the end of Project R. 7346, farmers re-iterated strongly their desire to grow disease-resistant, dual-purpose cultivars in Ananthapur district. Accordingly, the main purpose of Project R. 8339 has been to transfer integrated disease-management technology, based on superior cultivars, to farmers in the major groundnut-growing region of Ananthapur district.

If new cultivars are to be adopted successfully by farmers, then access to high quality seed is essential. For sorghum, the private sector can serve as a seed multiplier, following provision of information on the new cultivars. On the other hand, to achieve wide dissemination of groundnut seed, village-based systems of multiplication/distribution based on self-help groups of farmers with NGO participation need to be established. Farmers involved in the project were provided with training on improved crop/disease management technologies. Concurrently, on-farm measurements supported by laboratory analyses at the ICRISAT-ILRI were undertaken to define the availability and nutritive value of feed resources, assess the effects of plant diseases on groundnut production/quality and, hence, milk yield. Data on the economic advantages of

growing the new cultivars over traditional varieties would be generated as a result of surveys conducted in the project area.

Research Activities

1. Seed multiplication and distribution of selected disease-resistant, dual-purpose groundnut genotypes

During the 2003 wet season, 78 farmers in two villages in Ananthapur district participated in the seed multiplication/distribution of four new disease-resistant, dual-purpose groundnut cultivars (ICGV-89104, 91114, 92020, 92093), following integrated management of foliar diseases. Supplementary irrigation had to be applied because of the drought. The district received only 211 mm of rainfall compared to the average of 467 mm. Seed of the cultivars were re-purchased and re-distributed to increase the numbers of farmers participating in the activity. Seed multiplication was again initiated in the 2003-2004 post-wet season. Seed harvested in this period was used for further dissemination to 121 farmers for sowing in the 2004 wet season. About 40 kg of pods, sufficient to plant about 0.2 hectares, of the four cultivars were distributed to each farmer along with a crop management package. Following harvest of the 2004 wet season crop, five farmers in three villages and 10 new farmers in two further villages were identified to continue seed multiplication/distribution in the 2004-2005 post-wet season. ICGV-91114 was the cultivar most preferred by farmers, and demand for seed exceeded supply. To meet this specific requirement, several farmers with irrigation facilities began the multiplication of ICGV-91114 under the guidance of project scientists and NGO staff.

2. Quantity and quality of fodder and analysis of flow on farm

Haulms from four new cultivars and the local variety were harvested at the end of the 2003 wet season from the fields of participating farmers in Ananthapur district. Replicated samples were taken from one square metre plots. Yields were assessed and quality parameters analysed at the ILRI laboratory, ICRISAT headquarters, Patancheru. Flow of fodder resources in the study villages was evaluated by interviewing the households participating in the project through a structured questionnaire. The questionnaire elicited information on quantities of fodder/feed fed to different animals, relative importance of different feeds, sources of fodder /feed (home grown or purchased), milk yields and economics of milk production.

Again, at the end of the 2004 wet season, more than 350 samples of pods and haulms from improved and local varieties were collected from four villages for yield assessment and quality analysis.

3. On-farm assessment of animal productivity

In December 2003, a visit was made to farms participating in the project to explore the logistics of establishing milk production trials after the 2004 wet season. Thirteen farmers in three villages were selected for trials comparing the effects of feeding improved and local varieties on milk production.

4. Laboratory analyses

At the end of the 2003 wet season, groundnut haulms from the four improved cultivars and one local variety were collected from 18 farms in three villages. In January and February, samples of groundnut haulm and milk were collected from 13 farmers in three villages who participated in the feeding trials. Measurements were conducted on the nutritive value of the haulms and aflatoxin analysis of haulms and milk samples.

Laboratory fodder quality traits were measured using the techniques described for Project R. 7346. The laboratory measurements that predict animal performance accurately will be used for the development of near infra-red spectroscopy equations to provide a rapid, easy, non-destructive analytical tool for estimating the nutritive value of crop residues in the future.

5. Economic impact assessments of improved cultivars

Household surveys were undertaken to obtain quantitative and qualitative information from project farmers using a structured questionnaire. A stratified random sample, representing 15-20% of dairy farmers growing disease-resistant, dual-purpose cultivars and traditional varieties, was selected at three locations. Information was recorded on crop distribution, livestock and feed/fodder resources, the sale/purchase of crops and milk, perceptions about pod/haulm yields and disease effects, and preferred quality characteristics of improved groundnut cultivars. Detailed cost of cultivation data on improved and traditional groundnut varieties were collected for comparison of returns from growing improved varieties.

Improved vs. traditional groundnut cultivars: For computing the cost of cultivation, production and returns, the following cost concept was used: Cost A1[1] plus imputed value of family labour. The value of family labour was imputed on the basis of statutory wage rate and for own bullocks the actual market rental value for hiring a pair of bullocks was considered. The value of seeds, both owned and purchased, was calculated at prevailing market rates. The items of cost did not include depreciation on implements, farm buildings, land revenue or cesses and other taxes. Thus, the net returns are returns to land and management.

Over all impact: The impact of the new groundnut production technology is assessed using Partial Budgeting Approach. Here, the added costs and reduction in incomes, if any, due to the new variety are treated as costs of the technology and the added returns from both main and by-products and any other indirect benefits due to the technology like increased milk yield are treated as benefits. These have been worked out on a per hectare and per animal basis and then aggregated for the entire area where the new technology will be adopted. Adoption of the technology has been projected to grow at varying rates from 2005 through 2009, i.e., starting with 2% in 2005 and reaching 8% in 2009.

The additional benefits due to adoption of the improved groundnut technology include:

Incremental yield of pods for the projected area

Incremental yield of haulms and the number of additional animals it can support (since the haulm is being used as dry fodder for cattle, its value has not been considered as it is being used as an input in milk production)

Additional milk production due to feeding improved haulm, i.e., 0.4 kg /animal / day. extrapolated for the entire milk animal population the additional haulm can support for a year.

Thus the total value of incremental output of pods and the additional output of milk produced constitutes the total benefit derived from the improved groundnut technology.

Outputs

Output 1: *Farmers provided with seed of new disease-resistant, dual-purpose cultivars*

Achievements: Village-level seed multiplication/distribution schemes have been established to provide farmers with quality seed of the new disease-resistant, dual-purpose groundnut cultivars, as part of the integrated disease management strategy. Farmers recognise the attributes of the new cultivars and have participated enthusiastically in the process. As a result, during the life of the project, the area under

[1] Cost A1 includes following inputs in value terms: hired human labor; hired and owned bullock labor; hired and owned machinery charges; seed (purchased and owned); Farm yard manure (own and purchased); fertilizer; insecticide and pesticide; irrigation charges, and miscellaneous charges,

the new cultivars has increased markedly to 3,000 ha and, at current rates of adoption, will increase to 18,570 ha by 2006 and to 80, 000 ha by 2010-2011. Significant numbers of farmers took part in an orientation programme on farmer participatory disease management in dual-purpose groundnuts in 2004, and a stakeholder workshop in 2005.

The development of village-level seed multiplication/distribution systems has been a significant success. Some 214 farmers from 12 villages have participated in wet season and post-wet season multiplication/distribution of seed of the new disease-resistant, dual-purpose cultivars in the traditional groundnut-growing area of Ananthapur in the last two years. Seed multiplication/distribution has been undertaken in farmer participatory mode with self-help groups, including those of women. Farmers have contributed to village seed banks by returning twice the quantity given to them for planting. Farmers identified ICGV-91114 as the outstanding cultivar for both grain and haulm production/quality. Demand for seed is being created from farmers not participating in the project. Recently, traders have taken up seed multiplication with farmers on a buy-back basis, sensing high demand for the improved cultivar. By the end of this phase of the project (30.03.05), improved groundnut cultivars will be grown on some 3,000 hectares.

An orientation programme on the importance of farmer participatory disease management of dual-purpose groundnuts was held on the 28-29 June 2004 in Ananthapur district, in collaboration with the DAATTC (Andhra Pradesh Agricultural University extension service) and the RDT (Rural Development Trust, an NGO). About 150 farmers from five villages attended, and the programme was conducted in Telugu, the local language. The programme included discussions on foliar diseases, soil-borne diseases, mycotoxin contamination and their management. The dialogue between scientists and farmers helped in the planning of the participatory on-farm trials. Media interest in the event resulted in the publication of two newspaper articles in Telugu:

Agricultural Correspondent (2004). ICRISAT targets for aflatoxin management and attempts for seed improvement. In *Vartha*, 29 June.
Agricultural Correspondent (2004). Experimental validation of a new groundnut cultivar and research attempts to minimize aflatoxin risks. In *Andhra Jyothi*, 29 June.

A stakeholder workshop on integrated crop/disease management in groundnut for more pods, nutritious haulms and healthy milk was held in Ananthapur on the 3-4 January 2005. Some 140 farmers and scientists from the NARS, NGOs and ILRI-ICRISAT attended. The main objectives of the workshop were to review the findings of the project, obtain feedback and opinions from stakeholders (especially farmers) on the participatory mode of research and development, and to identify opportunities for further collaboration. Several project activities, particularly the village-based seed multiplication/distribution programme, were discussed in detail. The workshop was well covered by the local media and a number of newspaper articles in Telugu were published:

Agricultural Correspondent (2005). Agriculture development with fodder management. In *Vartha*, 4 January.
Agricultural correspondent (2005). High yields with improved varieties. In *Eanadu*, 4 January.
Agricultural Correspondent (2005). Cultivate improved groundnut varieties. In *Andhra Jyothi*, 5 January.
Agricultural Correspondent (2005). High yields with ICRISAT varieties. In *Bhoomi*, 5 January.
Agricultural Correspondent (2005). Farmers are interested to cultivate improved groundnut varieties. In *Vartha*, 5 January.
Agricultural Correspondent (2005). Farmers attitude should change. In *Eanadu* , 5 January.

Other information bulletins published under Project R. 8839 are:

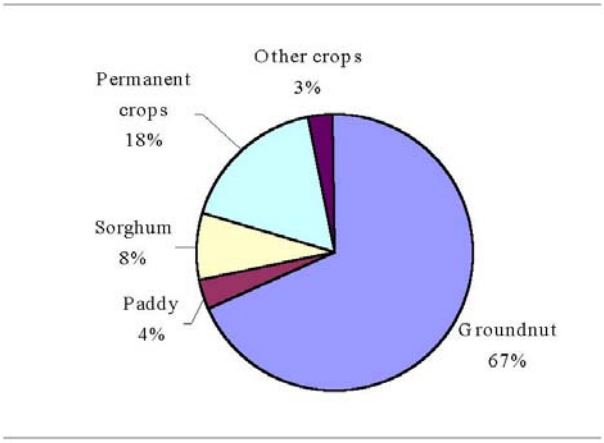
Pande, S., Narayana Rao, J. and Lakshmi Reddy, P. (2004). Groundnut diseases and their management in Andhra Pradesh, India. ICRISAT, Patancheru, Andhra Pradesh, India. 4 pp. (600 copies produced in Telugu; 20 copies in English).

Output 2: *Quantity, quality and flow of on-farm fodder resources in targeted villages defined*

Achievements: Measurements of the quantity and quality of groundnut haulm produced on the farms confirms the perceptions of farmers that yield and nutritive value of the new disease-resistant, dual-purpose cultivar ICGV-91114 is superior to that of the local varieties. Mean pod yields were 15% higher than those of the local varieties and haulm yields 17% higher.

Surveys of farmers in two project villages indicate that groundnut accounts for 61-75% of the cropped area under rain-fed conditions, (Figure 1). The balance is made up of sorghum (1-10%), paddy rice (1-6%), permanent crops (13-22%) and other crops.

Fig 1: Cropping pattern: Sample farmers Ananthapur district, 2003-04



Area under different crops

Crop	Area (ha)
Groundnut	161.8
Paddy	8.9
Sorghum	18.5
Permanent crops	42.3
Other crops	6.7
Total	238.2

More sorghum tends to be grown under rain-fed conditions rather than with irrigation. About 10% of the area of the sample farmers has been planted to improved groundnut cultivars promoted by the project. On average, farmers own 2-3 milk animals, and buffalo outnumbered cows. About 50% of households maintain a pair of bullocks for traction. The main sources of feed are residues of groundnut, paddy rice and sorghum, green grass from bunds (especially in the wet season), and forage from the grazing of common property resources and fallows. Groundnut haulms provide >50% of dry fodder, and >25% of the haulm fed to animals is traded (exchanged) within the village. Farmers are purchasing 75% of paddy rice straw and about 50% of sorghum stover from outside the village. In many cases, paddy straw is purchased from distances of 100-150 km away. Rice bran and concentrate mixtures are bought in the nearest town, and reserved for lactating animals and bullocks used for land preparation in the planting season. Compared to traditional varieties, ICGV-91114 is more resistant to diseases and drought. In an on-farm assessment of haulm and pod yields, the new cultivar ICGV-91114 significantly outperformed the local cultivars in three out of four villages. Across the four villages, mean pod yields were 2.57 t/ha for ICGV-91114 and 2.24 t/ha for the local varieties; an advantage of 15%. Mean haulm yields were 3.08 t/ha for ICGV-91114 compared to 2.64 t/ha in the local varieties; an increase of 17%. The farmers rated the palatability of the haulm of ICGV-91114, when fed to animals, as superior to that of local varieties.

Laboratory analyses of groundnut haulms from farms confirm that the feeding value of improved cultivars is high. The range of values for crude protein content, *in vitro* digestibility and metabolizable energy were 13.9-15.8%, 63.2-65.3% and 8.8-9.2 MJ/kg, respectively. Laboratory measurements were similar across cultivars and farms.

Output 3: *Effects of plant diseases on on-farm fodder resources and livestock productivity assessed*

Achievements: Farmers perceive that foliar diseases reduce pod yields in local varieties by 10-20% and haulm production by 20-30%. Farmers observed disease incidence annually, but pest incidence was observed once in two years. Milk yields in animals fed haulms from improved cultivar 91114 was about 10% higher than when animals were fed the local cultivars. In general aflatoxin content of feed refusals was higher than in feed offered, and re-feeding of refusals should be discouraged.

The disease aflatoxicosis in humans and animals is due to consumption of aflatoxin contaminated food and feed. Aflatoxin M1 is a major metabolite of aflatoxin B1 found in milk of animals that have consumed feeds contaminated with aflatoxin B1. Aflatoxin M1 contamination poses a significant threat of human health, especially to children who are major consumers of milk. Reports indicate that groundnut oilcake, haulms used in animal feeds contain high level of aflatoxin contamination. So it is essential to make sure the animal feeds are free from aflatoxin contamination so as to maintain the health of the animals and to get healthy milk also. To address these serious issues, milk yields and aflatoxin M1 contamination in milk was investigated in three villages in Ananthapur district, Lingareddypalli (5 farmers), Jalalpuram (5 farmers) and Talupur (3 farmers) in January and February of 2005 using groundnut haulms from local and improved cultivars harvested in the *Kharif* season (rainy season) of 2004. Collected were data on feeding of dairy animals, fodder samples, milk yields and milk samples. The fodder and milk samples were analysed for aflatoxin content. These data are to date not fully analysed but following conclusions can already be drawn. Milk yields in animals (Mostly buffaloes but also dairy cows) fed haulms from improved cultivar 91114 was about 10% higher (4.36 kg/d) than when animals were fed the local cultivars TMV2 and JL24 (3.92 kg/d). The advantage from growing improved cultivars is therefore threefold: 1) higher pod yields, 2) higher haulm yields and 3) higher milk yields from dairy animals fed the haulms.

However, close to 50% of the milk samples contained aflatoxin content of > 0.5 μg/kg, the threshold of non-permissible aflatoxin level of milk in India. Mean aflatoxin content in the milk samples was 1 μg/kg with a range of 0 to 15.4 μg/kg. Aflatoxin B1 content in fodder samples collected from the farmers in the three villages showed that all groundnut haulm/ fodder samples were below the threshold of 30 μg/kg for fodder. This might indicate responsiveness of farmers to ICRISAT recommendation to remove also the smaller pods – hotspots of aflatoxin – from the haulms. Only one fodder sample of groundnut cake collected from the three villages had non-permissible levels of aflatoxin B1 of 98 μg/kg. These finding confirm the importance of groundnut cake as a source of aflatoxin. However several of the refusal samples of groundnut haulms – i.e. the parts rejected by the animals – had levels of aflatoxin that approached the non-permissible level. If farmers re-offer these refusals the next day they would add aflatoxin load to the fodder. Such a practice might explain the apparently contradicting findings of below threshold levels of aflatoxin in the fodder while approximately 50% of the milk samples had above threshold levels of aflatoxin.

Further studies on aflatoxin content of groundnut haulms conducted by the DFID-funded project on aflatoxins in groundnut (R. 7809 - *Strategies for Reducing Aflatoxin Levels in Groundnut-based Foods and Feeds in India: A Step Towards Improving Health of Humans and*

Livestock) confirmed above studies on groundnut haulms. Seventy-two haulm samples from 6 groundnut varieties (ICGS 44, ICGS 11, DRG 12, ICGV 86325, ICGV 92020 and ICGV 92093) were analysed for aflatoxins contamination. The aflatoxin contamination in these samples ranged from 0-33 $\mu g\ kg^{-1}$. In total about 25% of the samples were found to be contaminated with the toxin but this was mainly contributed to one variety, ICGV 86325, while haulms from all other varieties were virtually free from aflatoxins.

Output 4: *Simple laboratory techniques for prediction of effects of diseases on livestock productivity developed*

Achievements: Laboratory measurements of nutritive value have been related to animal performance data using simple and multiple regression analyses. Laboratory measurements that predict animal performance accurately have been used for the development of near infra-red spectroscopy equations, to provide a rapid and non-destructive analytical tool for estimating crop residue feeding value.

Near Infrared Spectroscopy (NIRS) instrumentation has been calibrated for predicting nitrogen (i.e. protein) fiber constituents, *in vitro* digestibility and metabolizable energy content of groundnut haulms, sorghum stover and rice straw, the major fodder resources in Ananthapur district. From above described milk production trials in Ananthapur district in January and February 2005 fodder samples and refusals were daily collected, weighted, ground and subjected to NIRS analysis. Less frequently used supplements such as rice bran, green grass and groundnut cake were analysed by conventional laboratory analysis. The relationships between fodder quality traits as predicted by NIRS and conventional laboratory analysis and milk yields are currently investigated using multiple regressions procedures.

Output 5: *Comparisons of costs and returns of crop and livestock productivity without improved genotypes*

Achievements: Analyses have indicated that there are economic advantages in growing improved cultivars of groundnut in terms of increased crop and milk production. Gross and net returns on farm are higher and per unit costs of production are lower under both irrigated and rain-fed conditions. Seed is the most expensive input for production. Currently, farmers are receiving more for the sale of seed of improved cultivars than for traditional varieties. Milk yields from improved cultivars are higher than those from local varieties. Some 70-80% of milk is sold, and income from the sale of milk ranges from 15-25% at the household level. Thus the advantage from growing improved cultivars is therefore threefold: 1) higher pod yields, 2) higher haulm yields and 3) higher milk yields from dairy animals fed the haulms.

In 2003-2004, the groundnut crop on farms in Ananthapur was badly affected by drought, and a majority of farmers lost their crop, or ended with negative returns. The relative performance of improved groundnut cultivars was better but no firm conclusions could be drawn. In 2004-2005, the rainfall was good, and data were available from farmers for economic analysis. Nine farmers growing the local variety JL-24 and 37 farmers growing the most popular variety TMV-2 were asked for their perceptions of the new improved cultivar ICGV-91114. The results are presented in Table 2.

Table 2. Farmer perceptions of ICGV 91114 compared to traditional varieties

	ICGV 91114 with JL- 24	ICGV 91114 with TMV 2

	No difference	Slightly higher/ better (25%)	Much higher/ better (> 50%)	Lower than farmers' varieties	No difference	Slightly higher/ better (25%)	Much higher/ better (> 50%)	Lower than farmers' varieties
Grain yield	–	6	1	2	1	19	14	2
Fodder yield	2	6	1	–	1	32	1	2
Grain quality	–	8	–	–	–	35	1	–
Fodder quality	–	8	–	–	–	33	–	–
Fodder Palatability	–	7	–	–	1	20	1	–
Disease resistant	1	–	7	1	2	11	13	10
Pest resistant	6	3	–	–	21	15	–	–
Drought resistant	–	4	4	1	4	15	13	3
Labour inputs	9	–	–	–	36	–	–	–
Material inputs	8	1	–	–	36	–	–	–
Total Farmers	9	–	–	–	37	–	–	–

Source: Survey data

The majority of farmers growing both local varieties think that ICGV-91114 is superior in terms of grain/fodder yield, grain/fodder quality, palatability, resistance to diseases and drought tolerance by 25-50%. A majority of farmers think that there are no differences between cultivars in pest resistance, or in the inputs of labour/materials required to grow the crop.

The costs and returns from growing the improved cultivar ICGV-91114 or the local varieties JL-24 and TMV-2 in three villages under rain-fed or irrigated conditions are shown in Table 3. Pod and haulm yields were highest for ICGV-91114. Gross returns
were much higher for the new improved cultivar. Although the costs of cultivation were higher for ICGV-91114, the overall costs of production were 9% lower for the new cultivar under irrigation and 8% lower in the rain-fed situation. Net returns from the growing of ICGV-91114 were about 29% higher under irrigation and 25% higher under rain-fed conditions.

Table 3. Costs and returns for improved and local groundnut varieties: Ananthapur, sample farmers[1], 2004-2005

	Irrigated			**Rainfed[2]**	
	TMV2	**JL-24**	**91114[1]**	**TMV2**	**91114[1]**
Pod yield (kg/ha)	1322	1216	1567	1040	1231
Haulm yield (kg/ha)	1730	1730	2224	1483	1730
Gross returns (Rs/ha)	24291	24637	29450	19215	22541
Cost of cultivation (Rs/ha)	9558	10008	10472	8814	9561
Net returns (Rs/ha)	14733	14629	18978	10403	12981
Cost of production(Rs/kg)	7.2	8.2	6.7	8.5	7.8

1: Average of sample farmers from 3 project villages
Source: Survey data

Table 4 indicates the contribution of inputs to the total costs of cultivating either local varieties or the new cultivar ICGV-91114. Across cultivars, seed is the most expensive input accounting for 36-42% of total costs. Prices varied between cultivars, but differences were relatively small. In 2003-2004, there was a shortage of seed because of drought, so prices were higher. Labour is the next most expensive input accounting for 24-29% of total costs, followed by the cost of fertilisers (10-11%).

Surveys undertaken in three villages show that local cows produce 300-500 litres of milk per animal per year, and local buffalo 750-800 litres. On the other hand, annual milk yields in improved buffalo are 1100-1600 litres/animal. These yields explain why, in India as a whole, buffalo are becoming more important than cattle for milk production. Additionally, buffalo can be slaughtered at the end of their productive life in Hindu society, unlike cattle. Economics of milk production indicate that buffalo milk production is economical with an average per unit production cost of Rs. 6.5 per kg of buffalo milk (considering variable costs only).

Table 4. Contribution of inputs to total cost of cultivation for groundnut varieties, Ananthapur, sample farmers[1], 2004-05

	Irrigated			Rainfed	
	TMV2	**JL-24**	**91114**	**TMV2**	**91114**
			Percent to total cost		
Male labour	11.9	8.7	10.1	9.7	8.1
Female labour	17.1	15.3	15.3	17.2	16.8
Total labour	29.0	24.0	25.4	26.9	24.9
Bullock	8.9	8.8	8.0	10.3	9.1
Seed	35.9	40.9	40.5	38.1	42.4
Seed treatment	1.5	1.3	1.3	2.3	2.0
Fertilizers	11.4	9.9	10.5	11.2	10.4
Plant protection chemicals	3.9	5.1	3.5	3.2	2.8
Plant protection sprayer wages	1.2	1.4	1.1	1.4	1.4
Threshing	8.2	8.6	9.6	6.5	7.1
Total cost (Rs/ha)	9558	10008	10472	8814	9561

1: Average of sample farmers from 3 project villages
Source: Survey data

The impact that cultivar 911141 is likely to have on the production of groundnut in Ananthapur district has been studied based the performance of the cultivar in relation to the existing cultivars, i.e., TMV-2 and JL-24 the two prominent varieties in the region. The adoption rates have been assumed at very conservative levels of 2, 4, and 8 percent for the period 2005 to 2009 for both dry and irrigated groundnut. The area under groundnut in Ananthapur district is assumed to be stable at 0.8 million hectares per annum for the period of assessment. For the dairy enterprise it is assumed that 70% of the dry fodder requirement of milk animals is met by the haulm of groundnut and remaining 30% by paddy and sorghum straw. The price of pods is assumed at Rs. 16.50 per Kg and milk Rs. 9 per Kg.

On the basis of the yield and economic parameters estimated from the field and assumptions with regard to adoption, the economic implications of the improved cultivar have been assessed and are presented in Table 5. Accordingly, the incremental benefit during 2005 would be around Rs. 60.6 million that comprises Rs. 51.4 million due to groundnut crop and Rs. 9.2 million due to dairy. The incremental benefit progressively increases to Rs.121.3 in 2007 and Rs. 242.5 million in 2009. The cumulative benefit for the next 5 years is estimated at around Rs. 848.7 million.

Currently, farmers are receiving about Rs. 24-28/kg for seed of the improved cultivar ICGV-91114 compared to Rs. 18-22/kg for seed of traditional varieties. Milk yields per animal on farm are 0.44 kg/day higher with haulm ICGV-91114 than with the local varieties. Some 70-80% of milk is sold through both formal and informal channels, and income from sales ranges from 15-25% at the household level.

Table 5. Economic Implication of adoption of groundnut in Ananthapur district of Andhra Pradesh

Particulars	**2005**	**2007**	**2009**
Total groundnut area (000 ha)	800	800	800
Projected % area adopted under cultivar ICGV-91114	2%	4%	8%
Total rainfed area (000 ha)	760	760	760
Estimated area under cultivar ICGV-91114 (000 ha)	15.2	30.4	60.8
Total irrigated area (000 ha)	0.40	0.40	0.40
Estimated area under cultivar ICGV-91114 (000 ha)	0.8	1.6	3.2
Incremental Output of grain and haulm			
Pod production (tons)	3117	6235	12649
Haulm production (tons)	28075	56150	112301
Value of additional G.nut output @ Rs. 16.5 /Kg (million Rs.)	51.4	102.9	205.7
Incremental milk output			
Dry fodder requirement/animal/year (tons)	4.0	4.0	4.0
Of which haulm (70%)	2.8	2.8	2.8
No. of milch animals fed/year	9989	19979	39958

Incremental milk yield of these animals (tons)	1021	2042	4084
Value of additional milk production @ Rs. 9/Kg (million Rs.)	9.2	18.4	36.8
Total value of benefit (million Rs.)	**60.6**	**121.3**	**242.5**
Total value of benefit (2005 – 2009 million Rs.)	**848.7**		

Source: Calculation based on survey data

The total value obtained is the total benefits that accrue to the producer as a result of cultivating the variety. However, impact of this technology on the consumer will be felt in the medium term when there is a reduction is the market prices on account of the shift in the supply function for groundnut and milk. Estimation of the demand and supply functions and their shifts will be attempted in a more elaborate version of the study using field level data and appropriate statistical models. This will help in determining the gains to the producer as well as the consumer and judge the overall impact of the technology on the economy.

Contribution of Outputs to developmental impact

Projects R. 7346 and R. 8339 have made substantial contributions to the promotion of pro-poor strategies to reduce the impact of key diseases, improve yield and quality of crops and reduce mycotoxin hazards (in collaboration with Projects R. 7809 and R. 8298) in peri-urban/urban production systems. The new disease-resistant, dual-purpose cultivars will contribute to increased milk production and incomes at farm level and, hence, to improved livelihoods for small-scale farmers. The projects have been truly multi-disciplinary. There has been collaboration between plant, animal and social scientists of different disciplines from two CGIAR centres, collaboration between CGIAR scientists with those from the NARS, NGOs and government extension services, and farmers. The projects have progressed from on-station trials, through on-farm evaluations and trials, supported by laboratory analyses, to the adoption by farmers of new cultivars and the establishment of village-based seed multiplication/distribution schemes.

Project R. 7346 assessed the importance of plant diseases on the yield and nutritive value of sorghum and groundnut residues on station and on farm. New disease-resistant, dual-purpose cultivars were identified, and existing on-farm management practices to control diseases beyond the grain harvest period modified to improve the quality of the residues for dairy production. Project R. 8339 has disseminated seed of new groundnut cultivars in the major production district of Ananthapur using village-level seed multiplication/distribution systems. In this area, >50% of the dry fodder fed to animals is groundnut haulm. The new cultivars produce more pods and more haulm of higher nutritive value than traditional varieties. This has been confirmed by on-farm assessment and laboratory analyses. Additionally, evidence from Project R. 7809 has indicated that groundnut cultivars that show resistance to foliar diseases also show resistance to fungi responsible for mycotoxin production. Technologies to reduce mycotoxin contamination on farm, developed in the extension (R. 8298 - *Aflatoxin Contamination in Groundnut in Southern India: Raising Awareness and Transferring and Disseminating Technologies to Reduce Aflatoxins*) to R. 7809, are being simultaneously transferred to farmers in the region. The availability of good quality seed is currently the major constraint to an expansion of the area of new cultivars of groundnut. At the current rate of seed multiplication/distribution and adoption, as part of a new disease management technology, the area under the new cultivars of groundnut will be 3,000 hectares by March 2005. In Ananthapur district, about 850,000 hectares are under groundnuts (some 61-75% of the cropped area under irrigated and rain-fed conditions), so there is much potential for scaling up of the technology.

A further extension of the project has been agreed with the DFID-CPP. This would allow the project to continue activities for two more cropping seasons (one wet season and one post-wet season) with additional partners. This will contribute significantly to the scaling-up process,

reaching into the neighbouring state of Karnataka. By 2006, it is estimated that the area under the new cultivars will have expanded to 18,570 hectares.

Community-based seed delivery systems will be further developed and expanded to at least 1,500 farmers in the wet season and a further 50 with irrigation facilities in the post-wet season. Farmers and their associations will continue to be trained in quality seed multiplication/storage/distribution practices and in integrated crop/disease management strategies. The technologies will continue to be validated, demonstrated and popularised amongst farming communities along a number of diffusion pathways. The partners involved in Project R. 8339 - farmer self-help groups, NGOs (Rural Development Trust, Myrada, Rores) - will have their roles strengthened in the up-scaling process. Extension services of the State Agriculture University of Andhra Pradesh (DAATTC) and the Department of Agriculture are also partners. They will be responsible in overseeing seed multiplication/distribution and implementing disease management technologies in areas where the NGOs cannot reach. The National Dairy Development Board will be involved in promoting aflatoxin free milk for better health.

Recently, it has been observed that groundnut farmers are growing sorghum either as a border or intercrop. This is to reduce the damage to groundnuts caused by stem necrosis, a virus disease transmitted by thrips (*Thrips palmi*). The use of sorghum traps the insects and prevents the spread of the disease. This technique reduces losses in groundnut haulm and increases on-farm fodder supply from the sorghum. A promising sorghum cultivar (ICSV-700), identified under Project R. 7346 as being tall and well adapted to the local environment with high yields of good quality fodder, will be assessed for this purpose.

At current rates of adoption, it is anticipated that some 80, 000 hectares of groundnut (10% of the total crop) in Ananthapur district will be under improved cultivars by 2010, and that there will be dissemination of seed into the adjoining states of Karnataka and Tamil Nadu. Demand for high quality crop residues will increase in the future. The continued development of village-based seed multiplication/distribution systems, and the increasing interest shown by seed traders who have began multiplication of new cultivars with farmers on a buy-back basis, will ensure sustainability of the process even without external assistance.

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

Signature: sd/-
Name (typed): D. Ravi
Position: Scientific Officer (Statistics)
Date: 25.04.05