CROP PROTECTION PROGRAMME

Aflatoxin contamination in Groundnut in Southern India: Raising awareness and transferring and disseminating technologies to reduce aflatoxin

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FINAL TECHNICAL REPORT

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Executive Summary

Participatory processes, both pre- and post-harvest, have been successfully piloted with NGOs and farmers. Fourteen high-yielding aflatoxin resistant groundnut cultivars were evaluated in farmer participatory varietal selection trials in Anantapur, Chittoor and Mahabubnagar districts of Andhra Pradesh state. The fourteen lines tested were: ICGV 91278, 91279, 91283, 91284, 91315, 91317, 913124, 91328, 91341, 92302, 93305, 93328, 93379 and 94434. The varietal performance and farmer preferences varied with district. These varieties performed differently at Chittoor and Anantapur districts. Based on performance, farmers in Chittoor selected seven cultivars (ICGV 91279, 91284, 91324, 92302, 93305, 93328, 94434) and farmers in Anantapur six cultivars (ICGV 91278, 91315, 91328, 93305, 93379, 94434) for further on-farm testing. These cultivars produced 12-45% higher pod and haulm yields over their local controls in 2004, a moderately good year. Two varieties ICGV 93328 and ICGV 94434, produced 20-40% higher pod yield in 12 out of the 15 farmer fields in Piler (Chittoor District) area. Aflatoxin contamination was low in all the cultivars at all locations during 2003 rainy season. In 2004, three varieties (ICGV91284, 93328 and 94434) had low aflatoxin contamination. Seed from the large mature pods in most of the cultivars had negligible level of aflatoxin and high level of aflatoxin was found in insect damaged pods.

To promote awareness, flyers depicting the risks due to aflatoxins and technologies to minimize it were produced in English, Telugu, Hindi and French, and were disseminated to various stakeholders in India and West Africa. Awareness was also promoted to farmers, processors, NGOs, medical/veterinary doctors and government officials. Field days were organized in the villages of Anantapur and Piler Districts and several groups of farmers were addressed at ICRISAT center. Mechanical threshers were introduced for early pod stripping to avoid the stacking of the groundnut harvest, which enhances aflatoxin contamination. This intervention has provided a new perspective to the use of mechanical threshers as an aflatoxin management tool. Threshers were successfully modified to sort pods based on quality. Efforts were initiated to obtain government subsidy for purchase of mechanical threshers to benefit poor and women farmers. The benefits of mechanical threshing, which saves time and less drudgery have been demonstrated in two districts.

A panel was formed to develop strategies to promote aflatoxin awareness and it includes representatives from farmers, scientists, NGOs in agriculture and consumer markets, health officials, export bodies and government policy makers. This panel outlined an action plan to address the aflatoxin problem at various levels, mainly to evolve a ‘sensitive communication strategy for increasing awareness about mycotoxins’. AP State Department of Agriculture agreed to consider subsidies for purchasing threshers and sprinklers in the PVS villages. Medical professionals offered to workout plans for sensitizing medical staff and nutritionists about health-related risks due to aflatoxins.

Low-cost method for reducing aflatoxin contamination in groundnut has been tested on-station. This is based on application of compost, Trichoderma, gypsum, cereal residue and their combination. In variety JL 24, highest reduction in aflatoxin contamination from 390 to 36 $\mu g\ kg^{-1}$ (91%) was observed with gypsum +

Trichoderma application. Similarly application with cereal residue or gypsum, showed 12 to 40% reduction in aflatoxin level in JL 24. In variety J 11, gypsum + *Trichoderma* + compost application showed a reduction in aflatoxins level from 1509 to 8 $\mu g\ kg^{-1}$ (99%). Five other treatment applications (compost + cereal residue, compost + *Trichoderma*, gypsum + *Trichoderma*, compost + cereal residue + gypsum, and compost + cereal residue + gypsum + *Trichoderma*) showed 26-98% reduction in aflatoxins levels.

Background

Aflatoxins are highly toxic and carcinogenic chemical substances, produced by *Aspergillus flavus* and *A. parasiticus* on variety of agricultural commodities including groundnut. Aflatoxin contamination in groundnut has gained global significance as a result of their deleterious effects on human as well as animal health and its importance to international trade. Groundnut is a key commodity in the livelihood of the rural poor in semi-arid Andhra Pradesh, as source of food for human and livestock consumption, and as a source of income. Those households relying on groundnut as a major source protein or consuming milk or animals that fed on groundnut cake or haulms face potentially severe health risks. In recent report Katiyar *et al.* (2000) demonstrated the risk of population in India due to aflatoxin contamination with hepatitis B virus infection and impaired growth in young children due to aflatoxins in Africa (Gong *et al*., 2003). The economic implications of aflatoxin and its potential health threat to human as well as livestock, have clearly created a need to eliminate or reduce aflatoxin contamination in food and feeds.

Infection of groundnut by *A. flavus* occurs under pre-harvest, post-harvest and storage conditions. It is well known that growth of *A. flavus* and consequent aflatoxin production is dependent upon a number factors such as temperature, humidity and kernel moisture content. Crops growing in semi-arid climates where there is the likelihood of drought are particularly at risk to pre-harvest contamination. Likewise, high seed moisture contents during storage also increase the risk of contamination. There are several management options are available to reduce aflatoxins contamination in groundnut including cultural practices, genetic resistance, biological control and integrated management.

Project purpose

Promotion strategies to reduce the impact of pests and stabilise yields in semi-arid cereal-based cropping systems for the benefit of poor people

The purpose of the project is to: (i) test pre-and post-harvest technologies that reduce aflatoxin contamination and transfer these to farmers through a participatory process; (ii) to increase awareness of aflatoxin and its associated health risks, as well as technologies that reduce aflatoxin contamination, to stakeholders in the groundnut-based food and feed chain; and (iii) to develop and test low-cost technologies and integrated management practices that increase production and quality, and reduce aflatoxin

Research activities

Output 1: Pre and post-harvest technologies that reduce aflatoxin contamination transferred to farmers through PTD process

- Participatory processes, both pre- and post-harvest, have been successfully piloted with NGOs and farmers. Pre-harvest processes can be scaled up successfully as long as seed is available and the process does not demand too much quantitative evaluation. NGOs, self-help groups and farmers are enthusiastic about the process and the potential outputs
- Fourteen high-yielding aflatoxin resistant groundnut cultivars were evaluated in farmer participatory varietal selection trials in Anantapur and Chittoor district of Andhra Pradesh state: The fourteen lines tested were: ICGV 91278, 91279, 91283, 91284, 91315, 91317, 913124, 91328, 91341, 92302, 93305, 93328, 93379 and 94434. These cultivars produced 12-45% higher pod and haulm yields over their local controls. These varieties performed better at Chittoor than at Anantapur district, reflecting different weather patterns and hence yield potential. Based on performance, farmers in Chittoor selected seven cultivars (ICGV 91279, 91284, 91324, 92302, 93305, 93328, 94434) and six cultivars in Anantapur (ICGV 91278, 91315, 91328, 93305, 93379, 94434). Further on-farm testing is planned for 2005
- Aflatoxin contamination was low (0-7µg kg^{-1}) in all the cultivars at all locations during 2003 rainy season. In 2004, three varieties (ICGV91317, 93328 and 94434) had low (<5 µg kg^{-1}) aflatoxin contamination.
- Seed from the large mature pods in most of the cultivars had negligible level of aflatoxin; in contrast high levels of aflatoxin were found in insect damaged pods. Therefore sorting pods will be effective in reducing aflatoxin.
- Groundnut farmers' livelihoods, and the constraints affecting technology adoption, have been documented. Reports on local seed systems, information flows within villages and self-help groups have also been produced
- The seed supply systems in the study region and in Andhra Pradesh overall, presents a chaotic, fragmented and disorganized picture. Aflatoxin control requires interventions in such a way that seed supply systems are brought to a uniform level with some common minimum standards to ensure quality seed production. Quality seed supply should be the main aim here rather than aflatoxin free seed production per se as ensuring quality in general gradually ensures healthy seed as well
- The role of SHGs networks and NGO networks in faster dissemination of technologies and in providing equal access to the poor and women in the technological change process had been clearly established. There are large gaps in the information flows system due to which poor farmers invariably have much less access to new information, knowledge and skills as compared to the rich. Women farmers are worst placed. Greater attention will need to be given to these disadvantaged groups.

Output 2: Awareness of aflatoxin promoted and technologies that reduce aflatoxin contamination disseminated to government, NGOs, and private companies in the groundnut based food and feed chain

- Flyers depicting the risks due to aflatoxin and technologies to minimize it were produced in English, Telugu, Hindi and French, and were disseminated to various stakeholders. Interacted with farmers, processors, NGOs, medical/veterinary doctors and government officials to promote awareness about aflatoxin. Field days were organized in the villages and at ICRISAT Centre.

- Mechanical threshers were introduced for early pod stripping to avoid the stacking of the groundnut harvest, which enhances aflatoxin contamination. This intervention has provided a new perspective to the use of mechanical threshers as an aflatoxin management tool. Threshers were successfully modified to sort pods based on quality. Efforts were initiated to obtain government subsidy for purchase of mechanical threshers to benefit poor and women farmers.
- A panel was formed involving representatives from farmers, scientists, NGOs in agriculture and consumer markets, health officials and government policy makers. Two meetings were conducted which was attended by the higher officials of Department of Agriculture, Government of Andhra Pradesh, medical professionals and representatives of producers cooperatives, NGOs, marketing officials, processing industry and exporters. This panel outlined an action plan to address the aflatoxin problem at various levels, mainly to evolve a 'sensitive communication strategy for increasing awareness about mycotoxins'. AP State Department of Agriculture agreed to consider subsidies for purchasing threshers and sprinklers in the PVS villages. Medical professionals offered to workout plans for sensitizing medical staff and nutritionists about health-related risks due to aflatoxin.

Output 3: Low cost technologies and integrated management practices to increase production and quality and reduce aflatoxin developed

- Low-cost method for reducing aflatoxin contamination in groundnut developed. This is based on application of compost, *Trichoderm*a, gypsum, cereal residue and their combination using two cultivars. In JL 24, reduction in aflatoxin contamination from 390 to 36 $\mu g\ kg^{-1}$ (91%) was observed with gypsum + *Trichoderm*a application. Similarly application with cereal residue or gypsum, showed 12 to 40% reduction in aflatoxin level in JL 24.

Contribution of outputs

- The Panel has become instrumental in establishing pathways for concerted action to promote awareness about the aflatoxin problem in groundnut-based systems. It created a common platform for stakeholders to help each other in joint actions and exchange information about the pros and cons of various actions undertaken. A strong consensus on influencing policy makers to formulate suitable policies to build up capacities of the farmers as well as the extension agencies and streamline marketing mechanisms for the delivery of healthy groundnut crop and products has emerged.
- Through the Panel the Department of Agriculture, AP State (DoA) has agreed to establish ELISA-based aflatoxin diagnosis laboratories in major groundnut growing areas. The first facilities will be at ICRISAT campus and at their Anantapur Center. The demand for aflatoxin analyses in a wide range of crops is growing exponentially, and the independent laboratory at ICRISAT will provide this facility. The impact of the ELISA testing is and will continue to be substantial.
- The DoA has also initiated a new program - 'Crop Resources Group' – for the overall development and support to certain specified crops, including groundnuts. This group will promote awareness of aflatoxin and training in

detection of aflatoxin will be included in the training programs for the staff of the DoA. ICRISAT is providing this training. This shows a clear commitment from DoA to tackle the aflatoxin problem, which will be beneficial to groundnut and many other crops

- The adoption of new higher yielding, lower aflatoxin varieties will contribute directly to improved livelihoods for groundnut farmers. Seed is a simple technology well understood by farmers and there is a growing demand for new varieties from farmers and NGOs. This should positively influence DoA and others.
- Participatory processes and interactions with NGOs is already empowering and enabling farmers and NGOs to gain more access to information and technologies. This can only be beneficial over the longer term.
- Policy formulations are definitely necessary to provide price incentives to farmers for producing aflatoxin-free groundnuts and to improve their livelihoods through this change process. Linking farmers to markets, providing testing facilities, and greater understanding of constraints on both sides will contribute over the longer term to this aim.
- With the acceptance of the use of mechanical threshers by the farmers for early pod threshing as a technology intervention measure for reducing aflatoxin, STAAD had approached the Department of Agriculture (DoA) for extending the government subsidy on farm machinery for purchase of one thresher each for West Narsapur and Piler, the PVS villages. With help from Accion Fraterna/RDT and SAHAJEEVAN, and an additional subsidy of 25% of the cost of the machine from STAAD, women's self-help group in West Narasapur village and Ontillu (Piler) farmers SHG are now group owners of groundnut threshers. It is hoped to persuade DoA to extend this subsidy to groups (e.g. SHGs) as well as individuals.
- The Anantapur District Seeds & Oil Millers Association has agreed to conduct awareness meetings among their trader and processor members on the economic, social and trade related effects of aflatoxin contamination in groundnuts and groundnut products, with the Panel specialists, during the next cropping season as part of the Panel activities.
- STAAD and ICRISAT have a project proposal with APEDA, a Government of India support funding organization for export of agricultural produce and the Indian Oilseeds & Produce Exporters Association (IOPEA) for organizing production of aflatoxin-free groundnuts. Groundnut exporters and organisations are aware of EU limits are actively seeking assistance to tackle this problem.

- The premier state medical institution, Nizam's Institute of Medical Sciences (NIMS), has formulated programs to create awareness of aflatoxin related health problems among the medical practitioners. The Head of Medical Oncology department at NIMS, Dr. Raghunath Rao, an active member of the panel, has taken part in a state wide TV show on the effects of aflatoxins on the human body. Similar awareness programs are also planned to be broadcasted soon with the participation of other experts in the panel on the other issues concerning aflatoxins. NIMS will continue to collaborate to gather evidence on the ill effects of aflatoxin contamination on the human health. The widening awareness and participation of other disciplines in aflatoxin related problems is further evidence of the importance given to this subject.

- The ‘access’ related problems were clearly identified by ‘information flows’ study, ‘seed systems study’ and ‘SHGs study’ by STAAD. Alternative strategies for addressing the issue of equal access to the poor and women have been outlined. It was clear that SHGs, and other associations of farmers such as Rythu Mitra groups should be viewed as the potential stakeholders in the process of change. Thus poor farmers and women will have access to the new knowledge and technologies and hence will constitute an important component of the technology dissemination 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.

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

Signature:
Name (typed): Subhash Chandra
Position: Principal Scientist (Statistics) & Head (Bioinformatics)
Date: 11 May 2005

Outputs

Output 1: Pre and post harvest technologies that reduce aflatoxin contamination transferred to farmers through a PTD process

Activity : 1.1 Participatory varietal selection (PVS) programme with new, high yielding, early maturity and aflatoxin resistant cvs

Introduction

One of the possible means of reducing aflatoxin contamination of groundnut is the use of resistant cultivars. Several studies have established the presence of field resistance to seed infection by *A. flavus* in some cultivars. Resistance to pre-harvest field infection is particularly important in areas where late season drought stress is a common occurrence (Mehan et al., 1987; Mehan et al., 1991; Mexon 1983; Waliyar et al., 1994; Zambettakis et al., 1981).

Participatory processes were initiated in all three districts by the project partners. ANGRAU, University of Reading and ICRISAT facilitated the technology transfer process, while STAAD facilitated the socio-economic processes. The processes were carried out with the support and active participation of local NGOs – Rural Development Trust (RDT)/'Accion Fraterna' (AF) in Anantapur district, 'Sahajeevan' in Piler and Integrated Rural Development Trust (IRDT) in Mahaboobnagar district. Full details of work conducted in 2003/04 are given in the Appendices, along with Tables of data from 2004/05.

The PVS process was introduced as a continuation of Phase I activities in Anantapur and Chittoor (Piler) districts. Mahaboobnagar district was added to these two in 2003. All three districts are major groundnut growing areas where groundnut is predominantly grown under rainfed conditions in the kharif, though Mahaboobnagar has equal amounts of rabi groundnut. In the last three years, all these areas have experienced prolonged droughts due to which groundnut crop suffered severe yield losses and farmers' livelihoods were severely affected. Post-harvest processes were investigated in Anantapur district in 2003, and in Anantapur and Chittoor district in 2004.

To support the participatory processes and provide background information to the Expert Panel (Output 2), STAAD undertook several studies in Anantapur and Piler districts on Information Flows, Self-Help Groups and Seed Supply Systems. These reports are given in full in the Appendices and summarized elsewhere.

Pod and haulm yields

Materials and methods

During 2003 and 2004, fourteen high yielding and aflatoxin resistant/tolerant groundnut breeding lines were tested in farmers' fields using participatory technology development (PTD) processes in Anantapur, Chittoor and Mahaboobnagar districts of Andhra Pradesh. In this participatory varietal selection (PVS) process, the farmers, traders and oil millers were involved in selection of the varieties.

During the first year of the project (2003) three districts viz., Mahaboobnagar, Anantapur and Chittoor in Andhra Pradesh were selected. In each district three villages were selected. In each village three farmers were selected and briefed about the trials with the help of local NGOs viz., Integrated Rural Development Trust (IRDT) in Mahabubnagar district, Rural Development Trust (RDT) in Anantpur district and Sahajeevan in Chittoor district. The list of villages and farmers are enclosed in annexure – 1. Fourteen high yielding, aflatoxin resistant groundnut cultivars viz., ICGV – 91278; 91279, 91283, 91284, 91315, 91317, 91324, 91328, 91341, 92302, 93305, 93328, 93379, 94434 were evaluated along with local check (TMV 2) in each village. Each of the participatory farmers was given one kg of seed of each variety. The 14 varieties were distributed among three farmers in each of the selected villages (first farmer – 5 varieties, 2nd farmer – 5 varieties and 3rd farmer – 4 varieties). The plantings were carried out during the months of July and August with the help of local planting implements by adopting 30 x 10 cm spacing.

During second year of the project (2004), the PVS trials were confined to two districts only as the project team decided to drop Mahaboobnagar district. The trials were conducted in Anantapur district and Piler area of Chittoor district. Number of villages for trials was however increased to six in each of the two districts compared to three villages each during previous year. In Anantapur district apart from continuing the PVS trials in previous year's villages (old villages), three new villages were selected. The trials in the selected new villages were supervised by ANGRAU, where as the trials in the in the old villages were organized by the RDT (NGO) and the trials in Piler area (Chittoor district) were organized with the help of Sahajeevan (NGO). The trials, farmers and villages were divided into four groups in each district.

1. A set of farmer preferred/selected varieties (7 varieties in Chittoor and 6 varieties in Anantpur district) were planted in farmer fields where 2003 trials were taken up (old villages and old farmers) and the trials were tested in 3 farmers fields and 3 villages in each district. Each farmer was given 3 kg seed of each variety.

2. A set of all the 14 varieties was planted in 3 farmer fields and in each village 2 sets were sown. Three villages in each district were selected for this trial (new villages and new farmers) and 2-3 kg seed of each variety was given to the farmers.

3. A set of 14 varieties were planted in one farmer field, and 2 farmer fields in one village was used and 3 kg seed of each variety was given to the farmers.

4. All the varieties were tested in research stations at Anantpur and Tirupati

All the fourteen high yielding aflatoxin resistant cultivars that were experimented by the farmers in 2003 crop season were given opportunity to conduct the trials in 2004 crop season also. The seeds were distributed from the previous year (2003 rainy season) stocks preserved at ANGRAU in addition to those multiplied at ICRISAT campus.

One set of Gemini data loggers were installed in trial plots in each district to record air temperature, humidity and soil temperature in the pod zone during crop growth period. The experiment plots were kept weed free and protected from insect pests and diseases.

These on-farm trials were analysed using restricted maximum likelihood (ReML) treating village as a replicate and farmers within villages as incomplete blocks. The representativeness of the results obtained is conditional on how representative the farmers and their fields are of the target population.

Field days and evaluation

During 2003, 2004 crop seasons one field day in each district was conducted at 90 days after sowing with association of local NGOs and STAAD by involving all PVS trail farmers and other farmers. During the field days the farmers evaluated the varieties for their yield by uprooting the plants of 1.5 m row length. All the varietal samples plants were kept at one place and evaluated and rankings were given.

Collection of soil samples and estimation of *Aspergillus flavus* population

Ten random samples were collected within 20 m row for each variety and thoroughly mixed to make two composite samples for each variety. Aqueous soil suspension (1 gm of soil + 100 ml of sterile distilled water) was prepared from each of the composite samples and was serially diluted to 10^{-3} and 500 μl of soil suspension was spread on AFPA (*A.flavus* and *A.parasiticus* specific medium) plates @ 5 plates for each composite sample and incubated for four days at 28°C in dark. Typical *A.flavus* colonies were counted and colony density per gram of soil was determined.

Harvesting and sampling

In each variety, two rows of 10 m length were marked and harvested by uprooting the plants and allowed to field dry for 3-5 days. Then the pods were stripped manually and pod and haulm yields were estimated. The stripped pods were graded into 5 categories viz., Bulk, large, medium, small and damaged. Graded pods were shelled separately before analyzing them for *A. flavus* infection and aflatoxins contamination. In 2004 due to various reasons, proper sampling, sub-sampling could not be made for the analysis of seed infection and toxin estimation and the tentative results are presented. The samples from 2004 season are being analyzed second time for seed infection and aflatoxins estimation to confirm the first analysis results.

On-station trials

During 2003 and 2004 two on-station trials one each at Regional Agricultural Research Station (RARS) Tirupati and Agricultural Research Station (ARS) Anantapur were conducted.

Fourteen high yielding early maturing and aflatoxin resistant cultivars viz., ICGV – 91278; 91279, 91283, 91284, 91315, 91317, 91324, 91328, 91341, 92302, 93305, 93328, 93379, 94434 and TMV 2 local check were evaluated for their yield performance and resistance to *A. flavus* infection and aflatoxin. The experiment was conducted with 15 varieties replicated thrice in randomized complete block design (RCBD). The plots were kept weed free and protected from insect pests and diseases. One set of Gemini data loggers were installed in each replication for recording air temperature, humidity and soil temperature.

Harvesting and sampling

The plots were harvested separately at maturity (105 days) and allowed for field dry for 3-5 days and the pods were stripped manually and pod and haulm yields were estimated. The stripped pods were graded into 4 categories viz., bulk, large, small and damaged for seed infection and toxin estimation. *A. flavus* infection and aflatoxin concentration were determined using methods described by Waliyar *et al.* 2003.

Results and Discussion

PVS trials

The farmers evaluated the varieties during their crop growth period and field days based on the criteria viz., drought tolerance, early maturity, number of pods/plant, out turn (% shelling) and fodder yield with comparison with local variety TMV 2. The performance and farmers' preference for the varieties varied in Piler and Anantapur. During the 2003 crop season farmers preferred/selected varieties viz., ICGV 91279, 91284, 91324, 92302, 92305, 93328, 94434 at Piler and the varieties viz., ICGV 91279, 91284, 91324, 92302, 93305, 93328, and 94434, at Anantapur.

Testing of 14 varieties with different farmers

In this trial, 14 varieties were distributed in a village and three farmers in 2003 and 6 farmers in 2004 were selected.

During 2003 the yield levels were very low at Anantapur as the crop experienced severe drought. Only 227 mm of rainfall was received during crop growth period. During 2004 the crop experienced initial drought for 36 days. However, reasonably good yields were obtained due to uniform distribution of rainfall occurred during pod development stage.

Analysis of the pooled data indicated that there was no significant difference among the varieties with regard to pod and haulm yields. However, the varieties viz., ICGV 94434, 91324 and 93379, out yielded over local variety TMV 2 and find their place in farmers' evaluation also during field days (Table 1).

The *A. flavus* infection and aflatoxins contamination in 2003 rainy season was very low probably this could be due to severe drought conditions prevailed during crop growth period (Table 2). Under severe prolonged soil moisture stress condition the fungus could not multiply in the soil leading to lower infection and aflatoxins contamination. However, in 2004 the *A. flavus* infection ranged from 0.5 to 27% and aflatoxins contamination ranged from 2 to 653 $\mu g\ kg^{-1}$. The *A. flavus* infection was higher than the local check (TMV 2) in 6 cultivars in bulk seed, 4 cultivars in large seed, but the aflatoxins contamination was less than TMV 2 (322 $\mu g\ kg^{-1}$) in 13 cultivars in large seed. There was only one cultivar (ICGV 93379) that showed higher *A. flavus* infection and aflatoxin contamination than the TMV 2 and it is due to higher seed infection and aflatoxins level in only one field out of the six fields tested (Table 3).

Performance of selected varieties in Anantapur area in 2004

Farmer selected/preferred 6 varieties were tested in 3 fields in each village and tested in three villages (West Nasapuram, Mukundapuram and Mallapuram). Data presented in table 4 indicate that there is no significant yield differences in the cultivars over the check TMV 2, but the varieties like ICGV 94434, 93379 performed better in 4 of the nine fields. More over farmer preferred these varieties because of drought tolerance and good out turn.

The levels of seed infection by *A. flavus* in the bulk seed, large seed was more or less same in the selected varieties and the control TMV 2. It is strange to record higher levels of aflatoxin contamination in large seed of the selected varieties, this was due to very high level of aflatoxin contamination (in Mukundapuram, Mr. Sanjeevulu field samples showed 44 to 1588 $\mu g\ kg^{-1}$) from one of the nine fields (Table 5). In this field post-harvest drying was delayed due to obvious reasons of the farmer resulting higher aflatoxin contamination in large seed group. In small seed category ICGV 91278, 91315, 91328, 93379 and 94434 showed less aflatoxin in the range of 37-135 $\mu g\ kg^{-1}$ against 161 $\mu g\ kg^{-1}$ in the control TMV 2. It is not wondering to record high aflatoxin in seed from damaged seed in all the varieties, because insect damage make pod vulnerable to *A. flavus* infection and subsequent higher level of aflatoxins production.

Testing of 14 varieties in one field during 2004 in Anantapur

In this trial all the 14 varieties were planted in one field and two villages were selected and in one village (Rekulakunta) the trial was planted in 3 replications. Results of the replicated trial at Rekulakunta indicated that there was no significant difference in both pod and haulm yield with a maximum pod yield of 1049 and 923 kg ha^{-1} with cultivars ICGV 92302 and 91328 respectively. In West Narsapuram pod yields were higher (20 to 56%) in all varieties than the control TMV 2 except in one variety (Table 6).

The *A. flavus* infection was low at Westnarsapuram village with exception in ICGV 91283, 91328 (Table 7). At Rekulakunta village all the varieties showed higher seed infection than the control TMV 2, and only two varieties (ICGV 91315 and 91328) had non-permissible level (>30 $\mu g\ kg^{-1}$) of aflatoxins than control.

Performance of 14 varieties at research station in Anantapur during 2003 and 2004

The results at ARS, Anantapur revealed that there was no significant difference among the varieties with regard to their pod and haulm yield (Table 8). During the 2003 the *A. flavus* infection and aflatoxin contamination was negligible because of prolonged severe drought condition. During 2004, most of the varieties produced 10-20% higher pod yield over the control TMV 2. In 2004 most of the varieties including the check showed the seed infection in the range of 2-31%. Aflatoxins contamination in bulk and large seed samples of the most of the varieties was <10 $\mu g\ kg^{-1}$ with exception in ICGV 92302 in which about 512 μg kg^{-1} aflatoxin was detected (Table 9).

On-farm trials in Piler (Chittoor district) area

Testing of 14 varieties with different farmers

At Piler also no significant difference was observed among the cultivars with regard to pod and haulm yield. However, the varieties viz., 94434, 93305 and 91279 out yielded over local variety TMV 2 (Table 10).

In 2003, all the 14 varieties showed less seed infection (71-95%) than the control TMV 2 and aflatoxins contamination in all seed categories was low, this could be due to good, well distributed rainfall during the crop growth period (Table 11). In 2004, bulk seed sample category 13 of the 14 varieties showed less (28-80%) seed infection and 12 varieties showed less (24-100%) aflatoxins contamination against TMV 2 control. The damage seeds of all varieties showed high level of aflatoxin (13-2243 μg kg^{-1}) indicating that the insect damage to pod in the soil will break down the varietal resistance/tolerance against the fungal infection and subsequent aflatoxins production. Large seed from four varieties (ICGV 91283, 91315, 91317 and 93379) showed high level of aflatoxin (87-326 μg kg^{-1}) than the control TMV 2 (Table 12).

Performance of 7 selected varieties at Piler

The PVS trial results of the selected varieties at Piler during 2004 revealed that ICGV 94434, 93305 and 91279 produced significantly higher (20-39%) pod yield than local variety TMV 2 (Table 13). Moreover, ICGV 94434 produced higher pod yield (range 9-95%) in all the 9 farmer fields tested, followed by ICGV 93305, ICGV 93328 out yielded in 7 and 6 fields respectively.

The *A. flavus* infection ranged from 3 to8.3% in large seed category of the 7 selected varieties as against 13.3% in the control TMV 2 and aflatoxins contamination in these varieties ranged from 1 to 16 μg kg^{-1} against 155 μg kg^{-1} in TMV 2. Aflatoxin level in 2 varieties (ICGV 91284 and 91324) were very low (<3 μg kg^{-1}) from bulk seed samples and the remaining 5 varieties showed toxin contamination in the range from 164 to 383 μg kg^{-1}. The higher level of aflatoxin contamination in bulk seed of 5 varieties could be due to pod sampling method, as the bulk seed samples and other category samples were taken from different lots of the pod in the same variety (Table 14).

Performance of 14 varieties in one field in Piler

In this trial all the 14 varieties were tested in one field, and two fields were selected in one village. Evaluation of 14 cultivars at Piler showed significant difference in pod yield among 14 cultivars with maximum yield of 2167, 2158, and 1916 kg ha^{-1} with the cultivars of ICGV 93379, 91341 and 94434 respectively. But there was no significant difference with regard to haulm yields. However, highest haulm yields were recorded and maximum of 4525, 4434 and 4342 kg ha^{-1} with cultivars of 93379, 94434 and 93305 respectively (Table 15). *Aspergillus flavus* infection ranged from 0.5 to 32% in bulk and large seed samples, unfortunately the local control sample could not be collected for this trial for any meaningful comparison. Aflatoxins contamination was low (<13 μg kg^{-1}) in 12 of the 14 varieties (Table 16).

Performance of 14 varieties at RARS, Tirupati

The trial at RARS, Tirupati was replicated thrice with 14 varieties in both 2003 and 2004 crop seasons. The results of on-station experiment at Tirupati revealed that significant difference was observed among the varieties with regard to the pod yield in 2003. The variety ICGV 94434 recorded highest yield (1838 kg ha^{-1}) followed by 93305, 93379, and 92302 which are on par with each other (Table 17). The *A. flavus* infection and aflatoxins contamination in both the crop season was low in all category of seed samples (Table 18).

Performance of varieties in Mahabubnagar district during 2003 season

Very low yields were obtained at Mahaboobnagar district because of severe drought. However, the significant differences were observed among the varieties with regard to their pod and haulm yield. Highest pod and haulm yield was obtained with ICGV 92302 followed by ICGV 93379 (Table 19). In general the *A. flavus* infection and aflatoxins contamination was low in bulk and large seed sample, however, the aflatoxin contamination in 14 varieties was lower (88 to 99%) in small seed and damaged seed samples (85 to 95%) against the control TMV 2(Table 20).

Estimation of *A. flavus* population in the soil

Estimation of soil population of *A.flavus* from PVS on-farm trials at Piler, Mahaboobnagar and Anantapur revealed no much variation among the varieties for harbouring *A. flavus*. However, the population levels ranged between 1.8 x 10^{-3} to 6.7 x 10^{-3}/g of soil at Piler,1.1x10^{-3} to 5.7x10^{-3}/g of soil at Mahaboobnagar and 0.9 x 10^{-3} to 2.3 x 10^{-3}/g of soil at Anantapur indicating more population levels at Piler followed by Mahaboobnagar. It may be due to the prevalence of favorable conditions for survival and multiplication of *A. flavus* at Piler. With regard to on-station trials no much difference was observed in population levels at RARS, Tirupati and ARS, Anantapur (Table 21 and 22).

Farmer preference

PVS processes have been successfully used to evaluate and introduce new varieties into communities. Farmers in the three districts predominately grow TMV2, a variety introduced more than 50 years ago. Farmers have not been exposed to many new varieties, either because no good varieties exist and/or because the seed supply system cannot deliver new seed at an affordable price (see Seed Systems Report). There is a clear demand for new varieties from farmers and NGOs on behalf of farmers. Therefore a PVS process with new, aflatoxin resistant varieties from ICRISAT was initiated in 2003.

The objective was to test on-farm the performance and ascertain the perceptions and preferences of farmers (male and female) and traders/processors of the new varieties against their local varieties. It was recognised at the outset that varieties would have to be higher yielding than the local variety if they were to be accepted, as farmers are not aware of aflatoxin and the market does not offer any incentive to produce aflatoxin-free groundnut.

General Information

Evaluations

At harvest, plants were uprooted and all varieties under test put together for farmers to evaluate. Farmers who grew the varieties, other farmers in the village and traders were invited to evaluate the varieties. In 2003 farmers were asked about the characteristics of individual varieties and then to make selections. This was done individually to avoid undue group or peer influence. In 2004 the process was simplified to asking farmers which varieties they preferred and which they did not like, and why. This was done primarily so that NGOs could handle the process easily, i.e. not be data intensive, with the expectation that it would be scaled-up in subsequent years. In all three districts about 60 farmers evaluated the varieties in 2003 and x in 2004. The number of women farmers in 2003 was small, 7 at Anantapur and 15 at Piler.

Weather

2003 was a severe drought year in Anantapur with an annual rainfall of 233 mm compared with the 1993-2002 average of 634 mm. There were long, dry spells on several occasions (Fig. 1 and see below) and the crop was not sown until the first week of August. In contrast, rainfall at Piler was good with an annual total of 750 mm (Fig. 2).

The year 2004 was a much better year at Anantapur, with 516 mm annual rainfall (Fig. 1). The crop was sown in the second week of July. Nonetheless, there were still three long drought spells (Table 23) as about one third of this rain fell during the hot season preceding the kharif or monsoon rains. Rainfall was also good at Piler at 1030 mm.

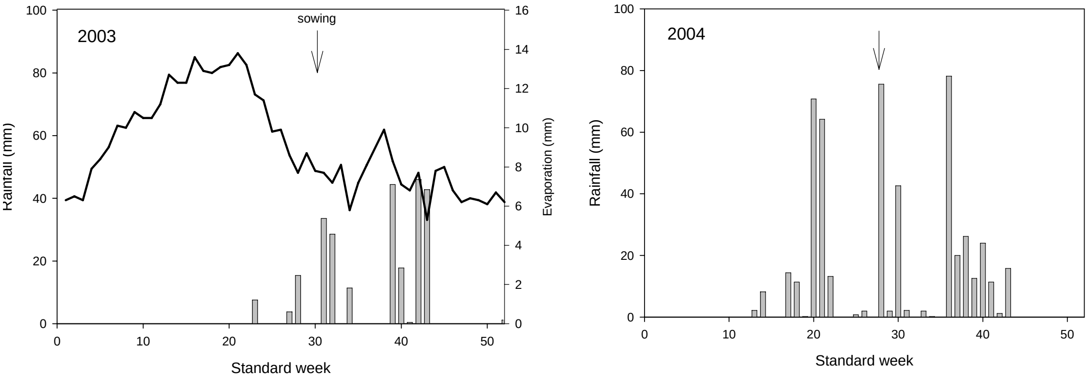

Figure 1. Rainfall (bars) and evaporation at Anantapur during 2003 and 2004

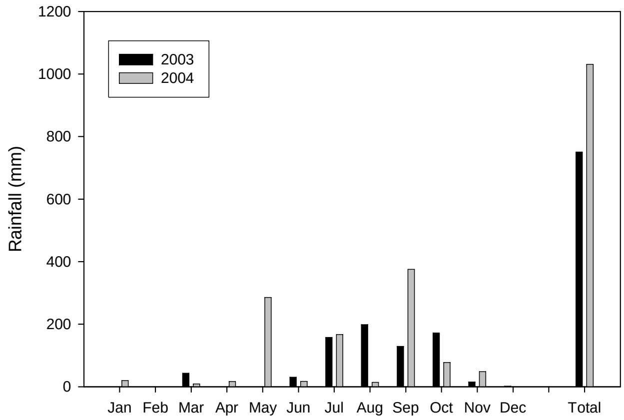

Figure 2. Monthly rainfall at Piler in 2003 and 2004

Farmer's choices

The varieties most frequently selected by farmers in 2003 and 2004 are given in Table 24. Male and female farmers made similar choices. In both years no single variety was preferentially chosen in all villages, and villages within the same district often selected different varieties. This was to be expected as the seasons were very different in the three districts. Farmers commented on a wide range of traits, with yield of pod and fodder, out-turn, boldness, colour, drought and pest resistance being mentioned most frequently.

Overall, in 2003 ICGV 94434 and ICGV 93305 were the most frequently selected varieties. However, farmers were somewhat reluctant to make a choice after one year and so all varieties were retained for 2004. Trader/ oil processors at Anantapur and Piler in 2003 preferred ICGV 91278 more frequently than other varieties, though again no single variety dominated selections.

Mahaboobnagar was dropped in 2004/05 as groundnut was not the main source of livelihood and farmers said they would prefer rabi types.

In 2004 five different varieties were preferentially selected (see below). Four varieties were disliked, particularly ICGV 91283. ICGV 91278 and ICGV 93305 were selected in both years, as was ICGV 94434 in some, but not all, villages. Although there was then no universal choice, there would appear to be 5 or 6 varieties that would be acceptable for further testing. This number of varieties is much easier to handle and evaluate. Hopefully, this smaller number of varieties will be tested further in 2005. Farmers would not normally make a choice based on one or two years evaluation, especially in drought-prone areas like Anantapur.

Future work and selection of cvs for 2005

Approximately 7 t of seed was purchased from farmers in 2004 for use in 2005. Based on two years of farmer preference data, yield trials, on-farm demonstrations and trials, 3 to 4 cvs were chosen for planting in 2005 (Table 25). These cvs, plus the local check TMV2, will be grown by 18 farmers in each district. Replicated yield trials will also be planted.

Activity 1.2 Participatory testing and promotion of early pod stripping, drying and sorting

During Phase 1, a number of possible post-harvest interventions were discussed with farmers, of which mechanical threshing/ stripping was given a high priority by farmers. Early threshing/ stripping will reduce the time pods and haulms are stacked in the field or yard, which in turn should reduce the period and hence risk of contamination, particularly if late season rains occur. Mechanical threshing also reduces drudgery, which was important to farmers. Therefore, mechanical threshers from ANGRAU were provided to one village in 2003 and three villages in 2004. The process of handing over the threshers was carefully monitored and a coalition of users established with the help of the local NGOs, RDT and Sahajeevan. This was to ensure community participation and sharing in an equable manner. These activities in 2003 are described fully in the Appendices.

The introduction of threshers was successful, more so in Anantapur in 2004 when threshers were provided earlier in the season and because the crop was better in 2004 than in 2003. Low yields in 2003 meant that for many small farmers it was not cost-effective to thresh mechanically; also hand-threshing allowed them to maximise fodder quality. Reported benefits included: better quality produce and hence higher price; earlier threshing, less labour and drudgery, more opportunity to earn money elsewhere; less problem finding space for stacking. Perceived disadvantages included: less time in stack reduces ‘outturn’ (i.e. post-harvest pod-filling), fodder quality poorer, broken and unfilled pods lost.

A thresher was also provided at Ontillu in Piler following discussions with farmers. Farmers at Piler were initially uninterested in threshers, but did agree a demonstration would be useful. A thresher was therefore sent to Piler where it was used by a few farmers free of charge. However, many more farmers observed the threshing and their perceptions were generally positive, especially about fodder quality and in contrast to farmers at Anantapur. It was noted though that moisture content was an important factor, moisture contents generally being higher at Piler than Anantapur due to the NE monsoon.

The introduction of threshers also showed that it was important to have an NGO or similar organisation to help agree how the thresher would be used and to ensure equitable access. Farmers are keen to own threshers, but the capital cost, even with government subsidy, is too much for SHGs. However, STAAD has obtained funds from DOA for two threshers, using community as well as STAAD funds to make up the difference. From 2005 there will therefore be one community thresher in Piler and Anantapur and their use will be monitored carefully.

Output 2: Awareness of aflatoxin promoted and technologies that reduce aflatoxin contamination disseminated to government, NGO and private companies in the groundnut-based food and feed chain (Activities 2.1, 2.2, 2.3)

Awareness, or rather lack of awareness of aflatoxin is a major issue. The lack of awareness makes it difficult to create a favourable environment for the adoption of aflatoxin reducing technologies. Furthermore, this lack of awareness appeared to be at all levels within the food and feed chain, and among policy makers and the general public.

The participatory processes introduced in the project provided the initial advantages to achieve the outputs - the participatory technology development (PTD) and the participatory varietal selection (PVS) - in the three districts of Andhra Pradesh. The positive results emerging from the crop management practices introduced and the favourable reception among the farmers and other stake holders towards the new practices provided the necessary support for undertaking awareness on aflatoxin contamination and promotion of aflatoxin reducing technologies among the government agencies, NGOs, farmers' self-help groups and various private agencies.

Awareness of aflatoxin, and the technologies available to reduce contamination, was promoted and disseminated to the stakeholders and policy makers in the groundnut food and feed chain. An advisory panel, comprising stakeholders from the private and public sectors concerned with all aspects of aflatoxin contamination, was formed to advise on an awareness strategy. Appropriate information tools and were produced for different groups of stakeholders to promote awareness of aflatoxin and awareness of technologies to reduce aflatoxin contamination.

Complementary studies were undertaken on the prevailing status of

1. 'Information flows in groundnut based cropping systems in Andhra Pradesh - an analysis of farmers perceptions',
2. 'Role of self help groups as potential units for networking of awareness promotion and technology dissemination to reduce groundnut aflatoxin contamination in Andhra Pradesh',
3. 'Groundnut seed supply systems in Andhra Pradesh - an analysis of farmers' perceptions and alternative strategies', and
4. Panel meetings were conducted and minutes documented for follow-up action

Reports on these studies are given in full in the Appendices.

Based on the perceptions of the farmers and NGOs as understood from these studies and their interactions during the PTD and PVS processes, tools and strategies for promotion of awareness on aflatoxins and the introduction of aflatoxin reducing technologies were developed, validated and promoted.

Materials and Methods

Three main activities were carried out by the project team to achieve the related outputs for which different approaches, materials and methods were used. These three activities were carried out in a mutually supportive manner as they were all aimed at achieving one common output of awareness promotion and technology dissemination to reduce aflatoxin contamination in groundnut based cropping systems. The materials and methods used were therefore complementary to each other and the related outcomes had overlapped each other. The methodology followed for each of the three activities are presented below -

2.1 A multi stakeholder approach was followed for formation of a Panel of members for evolving suitable strategies for awareness promotion on aflatoxin contamination and for dissemination of aflatoxin reducing technologies. The aim was to form a panel with 10-12 members, that included prominent institutions, agencies, and individuals that have influence over large sections of people. They should be able to play an important role in dissemination of technologies and awareness building.

One of the main considerations for selecting the panel members was their ability to evolve suitable strategies with their experience for wider dissemination and to carryout mass awareness campaigns. The panel was formed in such a way that it had players many among them also being key stakeholders in aflatoxin control process at various levels of supply chain of groundnut and groundnut products production, distribution and consumption.

The panel over a period of time was expected to become a watchdog as well as a force in articulating policies, bring large-scale awareness among producers, processors, traders etc. about health and economic risks of aflatoxin contamination. Thus paving a way for radical changes in the way people look at food safety and marketing practices as producers as well as consumers.

The panel in effect was to contribute to strategies for

- Dissemination of technologies
- Awareness building or campaigns
  And
- Guide developing appropriate information tools/methods for implementing these strategies

Each member's potential role was examined from the point of view of which of the roles mentioned above could they contribute to before they were included in the Panel.

2.2 Participatory studies were carried out with the men and women farmers of three districts in AndhraPradesh on the existing information systems of the groundnut based cropping systems. The main aim of these studies was to trace out the most effective means of communicating to the farmers in order to complement the validation process of the information and awareness tools developed by the project team. Studies were carried out in the same areas where dissemination process was going on through a PVS approach. Chittoor, Ananatapur and Mehaboobnagar districts were selected for this purpose and information was gathered from the rich, poor and women farmers categories in a participatory manner through focussed group discussions. Farmers perceptions from different categories were analysed in order to understand the accessibility of information sources and their effectiveness in building farmers capacities.

2.3 A number of key stakeholder groups have been identified: state and district level policy makers; consumer and health groups/NGOs; groundnut confectionary, oil, dairy and feed traders and processors; dairy industry, and groundnut farmers and NGOs supporting farmers. Specific studies were also carried out to assess the potential role of self-help groups and NGO networks in awareness promotion and upscaling technology dissemination to reduce aflatoxin contamination in the groundnut based cropping systems.

The entire information gathering process was carried out with the support and active participation of grassroot level NGOs – ‘Accion Fraterna’ (AF)/Rural Development Trust (RDT) in Anantapur district, ‘Sahajeevan’ in Piler and Integrated Rural Development Trust (IRDT) in Mahaboobnagar district. Nine villages were selected for study where PTD activities were carried out - Ontillu, Boddinayunidoddi, and Meddalachervupalem of Piler mandal in Chittoor district, West Narsapuram, Mukundapuram and Mallapuram in Anantapur district and Kethireddypalli, Rangareddygudem and Peddayapalli of Mahaboobnagar district.

Information was gathered through interactive discussions with members of self-help groups (SHGs) in the nine villages, local NGOs and from the concerned government offices including the Department of Agriculture, Govt. of Andhra Pradesh. Information was gathered from the village level offices as well as mandal level offices regarding the membership of various SHGs and lists of members obtained wherever possible. These membership lists were used to cross check the membership of each of the villagers, as many were found have membership in more than one SHG. The social groups and wealth groups of different members were ascertained wherever it was possible. Information regarding the aims, objectives and functioning of the SHGs was directly obtained from the SHGs themselves apart from the NGOs and government offices. Information about each of the development schemes under which SHGs were constituted were obtained from the respective websites of the programs through internet searches.

PTD process was used as an entry point to validate the information/awareness tools developed with the farmers followed by the Panel related activities and web site on aflatoxin to promote awareness among key stakeholders in groundnut supply chain and the consumers at large across India. Evaluations with farmers and traders helped to understand the effectiveness of the information disseminated by the project in controlling aflatoxin contamination through various improved pre and post harvest practices.

Results and Discussion (Outputs)

Activity 2.1 Panel formed to advise on awareness and dissemination strategy

Awareness of aflatoxin is on the rise. Activities undertaken by ICRISAT, ANGRAU, UoR and STAAD, under the project on reducing aflatoxins in groundnuts has created an impetus to this campaign. A few processors of groundnuts, traders of groundnut products, experts in medicine, media, various government departments and men and women farmers are concerned. The major constraints to the widespread awareness on aflatoxins are the invisible nature of the problem and lack of widespread availability of information on reducing aflatoxin contamination problem.

Issues of concern include the:

- possibility of promoting aflatoxin-free production and post-harvest processing technologies without any additional incentives to the farmers when there are no restrictions or regulations on the production, processing and trade of aflatoxin contaminated products,

- likely adverse impact on livelihoods of millions of poor and small groundnut farmers in South India due to aggressive campaigns on the problem due to which the possibility of being exploited by the processing industry and trade may increase, and
- possibility of withdrawal of a major source of proteins from the diets of millions of consumers in the region which pre-empts any major campaign on the ill effects of aflatoxins.

Based on the recommendations of the three-day workshop of groundnut stakeholders held during 27 – 29 Nov 2002, a permanent 'Panel' of the key stakeholders was formed. A multi stakeholder approach was followed for forming the initial group and for including the key stakeholders of groundnut supply chain as members of the Panel.

Members included representatives of the Government (Commissioner for Agriculture, Commissioner of marketing, among others), industry (Oil millers Association.), exporters (APEDA, IOPEA, ITC, etc.), NGOs, farmers (AP Co-operative Oil Seed Growers Federation), Representative of the Consortium of Consumer Associations, Dairy and Poultry Industry, Media, as well as medical and veterinary experts. All the partners of the DFID funded project on reducing aflatoxin contamination in groundnuts are also members of the panel.

The objective of forming a Panel was to

- establish sustainable participatory processes with networks of farmers and NGOs to up-scale awareness and dissemination of aflatoxin reducing pre and post-harvest technologies and to
- establish networks of key stakeholders and develop agendas for the promotion of awareness of aflatoxin and to influence the formulation of policies to produce and process aflatoxin-free groundnuts and products in South India

The Panel was also tasked to identify other key stakeholders and actions needed to raise the profile of aflatoxin at all levels. The Panel met in March and November 2004 and Action Points were agreed. In the first meeting a platform was provided to all the key stakeholders together, to discuss the magnitude of the aflatoxin problem, purpose of the Panel, elicit their views on the objectives of the Panel and establish a broad long-term action plan for to promote awareness.

The second meeting was a sequel to the first meeting where the members reviewed the commitments made by each of them, the constraints faced, revised the broad plans in to specific activities and agreed upon the mechanisms to implement the action plan.

Summary of proceedings of the first Panel meeting held on 7th April 04
The day-long meeting was organized to enlighten the members on the present status of the aflatoxin problem, ascertain their views on the need to and methods of building up awareness on a large scale, establish the activities to be undertaken, formulate action plans and establish the contributions and commitments of the members to the activities of the panel.

The first session was relegated to providing information on the current status of the aflatoxin problem and presenting the different perspectives of the problem to the divergent group. In the second session, members came up with their ideas on the necessity, approaches to and their role in tackling the problem, followed by an open discussion that resulted in outlining an approach of the panel to the problem. The overall approach to the problem included

- Listing out of and making no cost technologies accessible to the poor, reduce drudgery, and hasten the process of bringing in a change from the traditional methods of harvesting, encouraging supplementary irrigation during stress periods
- Build awareness among the processing industry on aflatoxin control technologies
- Link up production to exports
- Promote campaign for consumption of 'healthy food' rather than a direct anti-carcinogenic-generating-aflatoxin campaign.
- Involve as many people as possible in the process.

In the post lunch session strategies, approaches and action plans were formulated as presented in the Table 26.

Complete report attached in Appendices

Summary of proceedings of the second Panel meeting held on 5th Nov '04

The meeting was essentially called to review the program of activities and action plans as decided in the previous meeting and work out a time frames for each of the actions considered and the extent of involvement required by each of the different stakeholders for implementing the corresponding action points. Specific action required at the sub-panel level and identification of other stakeholders required for networking and effective execution of action plan needed to be worked out. Co-ordination and points of mutual cooperation required between members were also specified.

Out of the six strategies decided to be taken for action during the first meeting, it was decided, to first undertake activities under the strategy for sensitive communication. Promoting awareness on aflatoxin and capacity building / training in aflatoxin reducing technologies were to be the priorities for action and the target groups should be the farmers, extension personnel (Government + NGOs), consumers, processors (oil mill, decorticators, confectioners, feed /dairy, poultry feed), medical Practitioners & Nutritionists, Traders and Policy makers. It was decided to transfer the secretarial responsibilities of the panel to STAAD. The action plan is detailed in table 27.

Activities of the panel have started taking shape. A number of initiatives have arisen from these meetings. The department of agriculture has in principle agreed to establish ELISA technique based aflatoxin diagnosis laboratories in major groundnut growing areas starting with the first facility at ICRISAT campus and one more at their Anantapur Center. Depending on the response and reactions, further centers could be established within short time frames as the government is now well apprised of the plight of the groundnut farmers due to the high levels aflatoxins and a commitment to support the farming community with higher allocation of funds for infrastructure development.

Under a new program of the Department of Agriculture, Government of Andhra Pradesh, titled 'Crop Resources Group' created for the overall development and support to certain specified crops including groundnuts, the department of agriculture has included promotion of awareness on aflatoxin and training in detection of aflatoxin among the staff of Agriculture Department, who will be instrumental in propagating latest trends of crop management in the mandated crops. ICRISAT was requested to provide the necessary training to be conducted during May June 2005.

The Head of Medical Oncology department in the premier state promoted Nizam's Institute of Medical Sciences has formulated programs to create awareness on the aflatoxin related health problems among the medical practitioners through a series of workshops for various groups of medical practitioners and primary medical workers during April to June 2005.

STAAD and ICRISAT have a project proposal with APEDA, a Government of India support funding organization for export of agricultural produce and the Indian Oilseeds & Produce Exporters Association (IOPEA) for organizing production of Aflatoxin free groundnuts in large scale. ICRISAT and STAAD have also been participating in meetings and conferences organized on aflatoxin by various agencies.

The Anantapur District Seeds & Oil Millers Association has agreed to conduct awareness meetings among their trader and processor members on the economic, social and trade related effects of aflatoxin contamination in groundnuts and groundnut products during the next panel meeting which has been intended to be held in Anantapur during April 2005.

Complete report attached in Appendices

Activity 2.2: Information and awareness tools developed and validated in a participatory manner with target groups

From livelihood and market studies, and interactions with farmers and processors, it is clear that: (i) there is little or no awareness of aflatoxin or aflatoxin-reducing technologies among farmers and processors; (ii) farmers are reluctant to adopt technologies if they increase costs or, equally importantly, drudgery; and (iii) there is no incentive mechanism in the market to encourage the production of aflatoxin-free produce.

Focus group discussions with men and women farmers and with the rich and the poor within the farming community showed that in terms of sheer numbers, there are several formal and informal channels sources (fifteen and odd) from which farmers could avail information regarding agricultural production, new techniques and skills for adoption and improving crop productivity and their livelihoods.

Government extension program is the largest single source of information for farmers is considered as an inevitable source at present even though they are extremely dissatisfied with this service due to lack of alternatives of that magnitude and scale of operations. The subsidies offered to farmers on various inputs, seeds and agricultural machinery.

Backed by fertilizer and pesticide companies, input dealers (fertilizer and pesticide dealers) and traders of the crop produce are the most influential among the private formal channels of information. Mass media such as exclusive agriculture programs on the local TV channels and radio, agriculture journals and newspaper articles though have limited access, are the other important sources. One emerging trend however is the role of local NGOs in providing extension information and training to farmers in crop management as well as soil and moisture conservation practices.

There are large gaps in the system due to which

a) poor farmers invariably have much less access to new information, knowledge and skills as compared to the rich and
b) women farmers are worst placed (except for isolated cases such as women's exclusive 'janmaboomi programs' -disbanded at present- and exclusive women's training programs organized under the 'ANTWA' by the agriculture department).

An analysis of the responses given by the farmers indicates that Farmers generally like to get information closest to their residences. It is clear from these responses that farmers first prefer to emulate the practices undertaken by successful predecessors in the family or other co-farmers. When such first hand experiences are not available for visual observation, farmers are increasingly seeking advice from local NGOs who actively participate in the village development activities. NGOs that provide the services of technical personnel with high levels of interaction are the ones that farmers tend to depend upon during critical periods and for specific problem situations.

Media sources such as the TV, radio and newspaper form another major information source for the educated and the affluent farmers. The vast majority of farmers who are either illiterate or those who do not have access to the above sources generally depend upon the local fertilizer and pesticide dealers and traders for information.

Farmers in the study region indicated that they have been able to receive information from the agricultural department sources since a few years, due to the specific agriculture related Janmabhoomi programs (village level interaction with extension officials and experts) and when the farmers go to the agriculture department for subsidies on implements and inputs. However, farmers perceive that the agriculture department and the agricultural university are usually not important sources of information, despite the department's large extension network as interaction with the farmers by these agencies is rare and limited at village level (Table 28).

Dissemination strategies suggested
Against this background dissemination of aflatoxin reducing technologies require a two-pronged strategy. Initially the outreach to groundnut farmers should be through the existing informal networks of NGOs and farmers. A network of farmers groups of several congruent villages across a given location and networks of NGOs in a given location linking up several SHGs will be organized to pass on the knowledge on aflatoxin reducing technologies to the farmers.

The other facet of the strategy should be to utilizing the services of the large network of government extension through the 'ryotu mitra' groups (farmers clubs) introduced by the government and complemented by the use of 'information tools' developed under the project.

Among the emerging approaches to information flow systems to farmers, the concept of locale based information and communication technology (ICT) center is likely to be a most effective source that needs to be explored. The ICT could also act as a single window through which sustainable support systems such as supply of good quality inputs, providing weather forecasting and direct out-sourcing of aflatoxin free groundnuts for higher returns could be provided as integrated services to the farmers

Activity 2.3 Awareness of aflatoxin and aflatoxin reducing practices promoted among stakeholders

The study conducted by STAAD relating to information flow systems in the study region clearly indicates large gaps in the government extension systems in providing the farmers with the state of the art know-how in farming systems in general and the groundnut based livelihood systems in particular. Alternative arrangements had become a necessity through which farmers will be in a position to access the necessary information.

Similarly, access to inputs and infrastructure required for producing quality agricultural produce, especially aflatoxin free groundnuts, is not within the means of the small farmers in the study region. The study conducted by STAAD on the seed supply systems and use of threshers as a means of reducing post harvest control of aflatoxin has indicated the strong willingness of farmers for supply of good quality seeds at reasonable prices and low cost capital equipment for use in crop management practices.

Against this background, it was clear from the study conducted by STAAD on the role of self help groups (as potential units for networking of awareness promotion and technology dissemination to reduce groundnut aflatoxin contamination), that SHGs, and other associations of farmers such as Rythu Mitra groups should be viewed as the potential stakeholders in the process of change wherein poor farmers and women will have access to the new knowledge and technologies and hence will constitute an important component of the technology dissemination process.

It is expected that the project's main concerns about the poor and particularly women farmers being marginalized in the process of change could be addressed through introduction of technology interventions to the self help groups. This change however requires careful social organization to make the transition smooth and to ensure that the poor benefit from the changes.

To enable this to happen –

a) the grass roots level NGOs have to take the initiative to organize the multiple SHGs operating at village level into a cohesive group/network of common interest. The study of self-heop groups here showed that the SHGs are not only of different categories in each village but also that the number of SHGs under each category are many in number thus complicating the intervention processes. The more effective and prominent SHGs seemed to be the Velugu, Rythu Mithra and DWCRA groups as these groups do have a large majority of the farming communities – men and women as members at the village level.

In the groundnut thresher case, the project team has clearly seen that the NGO, Accion Fraterna/RDT has clearly demonstrated this in Ananatapur distict. A thresher committee was formed drawing members from different SHGs of the village which decided about the ways and means of sharing the thresher among groundnut farmers on a rotation basis. This process not only helped to achieve the project's goal of introducing 'early pod separation' as a practice but also disseminated the practice faster and gave a sense of ownership to the practice by the rich and the poor farmers. It considerably enhanced the prospects of women having improved access to the new knowledge besides making their participation more visible.

b) in order to consolidate the stakes of the farmers in the change process, the project team should pilot the NGOs to build up their own capacities in promoting awareness and aflatoxin reducing technologies. The PVS process has already made considerable contributions towards achieving this goal in and around the locations where PVS trials were held and local NGOs were involved. The NGO networks channels need to be activated for upscaling this activity in the region further. The project team also should facilitate the social organization process with the NGOs and SHGs before its withdrawl from the project study areas.

Another important means to reach out to the SHGs at large and the NGOs in particular, could be the 'Panel' that was formed by the project team to develop strategies for technology dissemination. The Panel should provide the platform for the NGOs and SHG networks to get access to the research institutions and other key stakeholders to articulate their needs for suitable technologies and for integrating themselves into the supply chain as important stakeholders. The membership of the 'Panel' should cater to this requirement to ensure continuity of the process after the project's withdrawal.

Government agencies should also be encouraged and their capacities strengthened to network with the SHGs for promoting awareness and upscaling dissemination of technologies rather than depending only on their conventional ways of reaching out to individual farmer to farmer basis.

SHG's role in the thresher case

The significance of SHGs as a target group was clearly established by STAAD in the threshers case as a post harvest intervention for promoting early pod stripping. Farmers clearly expressed that the mechanical thresher was handy to facilitate early pod stripping and found the overall economics working towards their favour. Since the entire process was deliberated by the project team on a sharing concept, access to thresher on a permanent basis has greater probability of sustaining the practice of early pod stripping in Anantapur and Chittoor districts.

STAAD's assessments with farmers of West Narsapur and Piler this year revealed their enthusiaism with using thresher to speed up pod stripping. They are very keen to own threshers for this purpose but expressed their financial helplessness to even pool up enough resources with government subsidy for buying a thresher. In order to sustain this enthusiasism and to promote the project's goal of early pod stripping, STAAD approached AP govt’s Department of Agriculture (DoA) for a sanction of government subsidy for purchase of one thresher each for West Narsapur and Piler. DoA has finally approved it and it was up to us now to make this happen.

STAAD managed a deal with RDT and SAHAJEEVAN finally, in that they would negotiate with farmers to agree to pay 50% of the balance of the sum that is to be paid to the suppliers after the govt.subsidy amount was subtracted from the original cost. STAAD had offered to pay the rest of the 50% amount from its tiny development fund. This meant that, of the total cost of about Rs.60,000/- for the new thresher, govt.'s susbsidy would cover Rs. 30,000 and the rest of the money would be paid by farmers and STAAD in equal amounts.

STAAD however, insisted that the thresher ownership should go to a self-help group and preferably to a women's group. While RDT closed the transaction with the supplier for the women’s group of West Narasapur village by collecting the money from their members and STAAD and paying it up to the supplier, they are also helping Sahajeevan close the deal with the same supplier for Ontillu farmers also, so that both the machines could be supplied at the same time.

Once these machines are delivered, they will be handed over to the groups formally, after clearly establishing the terms for ownership and use by the members who have contributed for the purchase of the threshers. With RDT in the lead and Sahjeevan toeing its line, we were in the process of finalizing this deal while this report was being drafted. Once the dates for handing over the machines are finalized, project members will be informed. STAAD had decided to go ahead with its share of contribution as it felt the dire necessity of the farming community that had helped it and the project members undertake the research activity enthusiastically and without and direct benefits and also since there is no allocation for this kind of transaction in the project budget and we were keen to ensure a continuum to the process initiated under the project.

We will be in a position to ensure some good outputs in 2005 if the project gets the extension. It will also give us an opportunity to observe the benefits of using mechanical threshers (supplied through the subsidies) as a means of reducing aflatoxin contamination by undertaking early pod stripping as a technological intervention. It will also be possible to ascertain the benefits derived by the marginal, small, medium and women farmers from the use of their own threshers – a means that was not available earlier – and how they shift from the practice of storing the entire harvested crop before undertaking pod stripping activity.

Extension of the project will also provide for undertaking interesting observations on how these farmer groups react to using machinery and equipment under a group ownership and their reactions based on the patterns of contributions as well as the possibilities and constraints to replicate this model on a larger scale.

Towards a better seed supply system

The seed supply systems in the study region and in Andhra Pradesh overall, present a chaotic, fragmented and disorganized picture. Aflatoxin control requires interventions in such a way that seed supply systems are brought to a uniform level with some common minimum standards to ensure quality seed production. Quality seed supply should be the main aim here rather than aflatoxin free seed production per se as ensuring quality in general gradually ensures healthy seed as well. This will be a long drawn process.

In the immediate future, new groundnut varieties should enter into the seed supply systems through social organization of NGO sector and/or private enterprises. NGOs should mobilize farmers self help groups and particularly women's self help groups to produce quality seed and establish networks to supply them in larger areas. This will have a double-edged benefit – a) it will increase farmers' awareness about quality seed and b) it will enable the poor farmers to be stakeholders of the seed supply systems thus enhancing their access to quality seed considerably. Simultaneously, private enterprises should mobilize farmers at village level to produce quality seed in such a way that some niche areas/clusters of villages might emerge as seed producing zones. This process requires price incentives to ensure quality seed supply. Initially, 'niche markets' might emerge where good quality seed is available at a premium price but gradually these markets might get integrated into as the main seed supply systems.

New legislative changes are in the offing related to seed quality in India in general and in Andhra Pradesh in particular. A new seed act is expected to bring in uniformity in the seed supply as it prescribes minimum standards along with penalties for bad quality for seed delivery across the state. It is not clear at this point how the new seed industry/system emerges after these regulations. As these changes will take a long time to be put in to practice, we have no choice but to rely on the options discussed above for seed multiplication and to ensure quality seed supply.

Conclusions

Panel, with its multiple stakeholder membership was instrumental in establishing pathways for a concerted action to promote awareness about aflatoxin problem in groundnut based systems. It created a common platform for stakeholders to help each other in joint actions and exchange information about the pros and cons of various actions undertaken. A strong consensus emerged that policy makers should be influenced to formulate suitable policies to build up capacities of the farmers as well as the extension agencies and streamline marketing mechanisms for the delivery of healthy groundnut crop and products. The policy makers in the Panel responded positively to the concerns expressed by the members and made initial commitments to the policy that will benefit the groundnut farmers at large. The recognition of awareness promotion as a 'sensitive communication issue' was a major stepping stone in addressing the issue of likely adverse impact on livelihoods of millions of poor and small groundnut farmers in India due to aggressive campaigns on the problem due to which the possibility of being exploited by the processing industry and trade may increase. The Panel was able to evolve alternative strategies to overcome this issue as discussed in 2.1 and to continue with awareness promotion efforts. This also addressed the issue of possibility of withdrawal of a major source of proteins from the diets of millions of consumers in the region which pre-empts any major campaign on the ill effects of aflatoxins.

The 'access' related problems were clearly identified by 'information flows' study, 'seed systems study' and 'SHGs study' by STAAD and alternative strategies for addressing the issue of equal access to the poor and women were outlined. The role of SHGs networks and NGO networks in faster dissemination of technologies and in providing equal access to the poor and women in the technological change process had been clearly established. Policy formulations are definitely necessary to provide the price incentives to farmers for producing aflatoxin-free groundnuts and to improve their livelihoods through this change process.

Output 3: Low cost technologies and integrated management practices to increase production and quality and reduce aflatoxin, developed

Activity 3.1 : Management of aflatoxin contamination by composts and anti-fungal bacterial isolates

Testing of low cost management technologies in farmers fields in Anantapur

Several research reports indicate that cultural practices such as application of farm yard manure (FYM), gypsum, crop residues and application of several bio-agents such as non toxigenic strains of *A.flavus, Trichoderma*, *Bacillus* and *Pseudomonas* reduce the aflatoxin contamination. Hence the components viz., farm yard manure, gypsum and *Trichoderma viridea* alone and integration were tested through participatory technology development (PTD) process.

Materials and methods

The trial was conducted at village Rekulakunta of Anantapur district. Ten farmers' fields were selected for the purpose. The following components were tested at each farmer's fields by adopting plot size of 10 x 10 m.

Components

1. Application of farm yard manure @ 5 t/ha
2. Application of Trichoderma @ 150 kg ha^{-1}
3. Application of gypsum @ 500 kg ha^{-1}
4. Components 1 + 2 + 3
5. Farmers' practice (control)

FYM was applied at the time of field preparation by incorporating the soil. The plantings were carried out during first week of July. The components viz., *Trichoderma viredea* and gypsum were applied in adjacent to the rows at 40 Days After Sowing (DAS). The plots were kept weed free and protected from insect pests and diseases. Harvestings were carried out during second week of November 2004 by uprooting the plants and allowed them to field dry for three days. Later the pods were stripped manually and pod and haulm yields were recorded. The stripped pods were categorized into three groups' viz., large, small and damaged for toxin estimation.

Results and discussion

No significant difference was observed among the treatments regarding pod and haulm yield and *A. flavus* infection and aflatoxins contamination was also very low to draw any conclusion (Table 29).

Testing new technologies for aflatoxins management at ICRISAT-Patancheru center

The problem of aflatoxins contamination in groundnut is endemic to rain-fed groundnut facing end season drought. Since there is good correlation between drought and aflatoxins contamination in groundnut, any treatments addressing the drought is highly likely to reduce the aflatoxins contamination. So with this intension using low cost options to manage the groundnut aflatoxins contamination, a field trial was laid out at ICRISAT-Patancheru center and the experimental details are as follow.

Experimental design

Location: ICRISAT-Patancheru

Objective: To develop integrated management practices to reduce the aflatoxins contamination in groundnut

Treatments (main plots):

1. Compost application (5 t/ha)
2. Cereal residue application (5 t/ha)
3. Gypsum application (500 kg ha^{-1})
4. Bio-control agent (*Tricoderma*)
5. Compost + Cereal residue
6. Compost + Gypsum application
7. Compost + Bio- control agent
8. Cereal residue + Gypsum
9. Cereal residue + Bio-control
10. Gypsum + Bio-control
11. Compost + Cereal residue + Gypsum
12. Compost + Cereal residue + Bio-control
13. Cereal residue + Gypsum + Bio-control
14. Gypsum + Bio-control + Compost
15. Compost + Cereal residue + Gypsum + Bio-control

Treatment application (sub-plot)

1. No application (control)
2. Treatment application

Genotypes (sub-sub-plot)

1. JL 24
2. J 11

Replications: Three
Experimental design: Spilt-Spilt-plot
Block structure: 15x2x2 x 3 reps
Plot size: 4 x 4 m, flat bed
Inoculation: Highly toxigenic strain (AF 11-4) of *A. flavus* was multiplied on pearl millet seed in the laboratory was broadcasted before groundnut planting, followed by row application of inoculum at 40 and 60 days after sowing.
Drought: Terminal drought was imposed for about 30 days before harvest, to facilitate the seed infection and aflatoxins contamination.
Plant protection: The crop was sprayed once with Kavach to control the foliar diseases
Observations: Weather parameters including soil temperatures, humidity, air temperatures and rainfall were recorded, Pod and haulm yield, seed infection by *A. flavus* and aflatoxins contamination

Results and discussion
2003 crop season
Pod yield: Groundnut aflatoxins management trial at ICRISAT-Patancheru center was harvested by lifting and the pod along with haulms were dried under the natural sun light for 3days in field using windrow method. Unfortunately the trial was badly affected by bud-necrosis virus disease and the disease incidence ranged 50-86% in the experimental plots. This resulted in non significant differences in the pod yield (Table 30).

Groundnut pod samples were collected from each treatment and sub-samples were analyzed for *A. flavus* infection and aflatoxins contamination. The imposition of terminal drought was not successful because of un-seasonal rainfall. In bulk samples *A. flavus* infection ranged from 1 to 15% and aflatoxins contamination ranged from 0 to 448 $\mu g\ kg^{-1}$ across the treatments and genotypes. The results obtained from this experiment were more erratic (in some situations the *A. flavus* infection and aflatoxins contamination was more in treatment applied plots) and probably this could be due to unevenly distributed bud necrosis disease and failure to impose the end season drought condition. However, reduction of >98% in aflatoxins contamination was observed in plots with compost + cereal residue and gypsum + bio-control + compost in JL 24. Similarly two other treatments (compost + cereal residue + gypsum and compost + cereal residue + Bio-control) led to 68-92% reduction in aflatoxins contamination in JL 24 (Table 31). Most of the seed samples from large pod showed negligible amount of aflatoxins across the treatments in both genotypes with few exceptions (Table 32). In seeds from medium size pod category, 74 to 98% reduction in aflatoxins level was observed with three treatments (compost, or bio-control agent or gypsum + bio-control + compost) in JL 24 and one treatment (gypsum + bio-control + compost) in variety J 11 (Table 33). In case of seed from small pod category 4 treatment applications showed reduction (45 to 99%) in aflatoxins contamination in JL 24 and one treatment in J 11 showed reduction in aflatoxin contamination (Table 34). Pre-harvest insect damage to groundnut pod results in high aflatoxins contamination. Soil inhabiting pests mainly pod borers, termites cause <1% pod damage before the crop was harvested. Kernels from damaged pods had >319 μg kg^{-1} mean aflatoxins level which is 10 times higher than the normal situation. It indicates the treatments may not be effective for damaged pods, as these pods are highly vulnerable to infestation (Table 35).

2004 Crop season

Due to peanut bud-necrosis disease ranging 30-60% in different plots, we could not observe any significant differences in pod yield in relation to treatment application (Table 36). Groundnut pod samples (bulk sample) from each plot were taken and sub-samples were processed for *A. flavus* infection and aflatoxins contamination. The *A. flavus* infection ranged from 0-5% and aflatoxins contamination ranged from 1-2471 μg kg^{-1} across the treatments and genotypes. Highest reduction in aflatoxin contamination from 390 to 36 μg kg^{-1} (91%) was observed with gypsum + *Trichderma* application in variety JL 24. Similarly two other treatment applications (cereal residue or gypsum) showed 12 to 40% reduction in aflatoxin level in JL 24. In variety J 11, gypsum + *Trichoderma* + compost application showed a reduction in aflatoxins level from 1509 to 8 μg kg^{-1} (99%). Five other treatment applications (compost + cereal residue, compost + *Trichoderma*, gypsum + *Trichoderma*, compost + cereal residue + gypsum, and compost + cereal residue + gypsum + Trichoderma) showed 26-98% reduction in aflatoxins levels (Table 37).

Groundnut pod from each plot was sorted in to large, medium, small size and insect damaged pods. Shelling of the sorted pods was done separately and sub samples were analyzed for *A. flavus* infection and aflatoxins contamination. Kernels from the large size pod from most of the plots contain negligible (<10 μg kg^{-1}) level of aflatoxins in both the cultivars. However, application of gypsum + *Trichoderma* application in JL 24 showed reduction in aflatoxins level from 588 to 7 μg kg^{-1} (99%) and two other treatment applications (cereal residue or cereal residue + *Trichoderma*) also showed 62-96% reduction in aflatoxins levels (Table 38).

Groundnut seed from medium size pods showed 0-6% infection and aflatoxins ranged from 0-1572 μg kg^{-1}. Most of the treatment applications in both the cultivars showed reduction in aflatoxins contamination raged from 43 to 99%. In variety JL 24 six treatment applications (compost + *Trichoderma*, cereal residue + *Trichoderma*, gypsum + *Trichoderma*, compost + cereal residue + *Trichoderma*, gypsum + *Trichoderma* + compost and compost + cereal residue + gypsum + *Trichoderma*) showed >90% reduction in aflatoxins contamination. In J 11, four treatment applications (gypsum, cereal residue + *Trichoderma* + gypsum, gypsum + *Trichoderma* + compost and compost + cereal residue + gypsum + *Trichoderma*) also showed >90% reduction in aflatoxins contamination (Table 39).

Seed from small size pods showed 0-11% *A. flavus* infection and 1-1300 μg kg^{-1} aflatoxin. Nine treatment applications showed 20-99% reduction in aflatoxin level in each cultivar. Seeds from insect damaged pods showed 105-5323 μg kg^{-1} aflatoxins in various treatments in both the cultivars (Table 40). In general the toxin contamination level is very high in seeds from insect damaged pods, because the fungus penetrate the pod easily and treatments may not be very effective in reducing the seed infection and subsequent aflatoxin production. However eight treatment applications in each variety showed reduction in aflatoxin contamination (Table 41).

REFERENCES

Gong, YY., Egal,S., Hounsa, A., Turner, PC., Hall, AJ., Cardwell, KF., and Wil, CP. 2003. Determinants of aflatoxins exposure in young children from Benin and Togo, West Africa: the critical weaning. International Journal of Epidemiology, 32: 556-562.

Mehan, V.K., McDonald, D., Haravu, L.J., and Jayanthi, S. 1991. The groundnut aflatoxin problem : review and literature database. Patancheru 502 324, Andhra Pradesh, India : International Crops Research Institute for the Semi-Arid Tropics. 387 pp

Mehan, V.K., McDonald, D., and Rajagopalan, K. 1987. Resistance of peanut genotypes to seed infection by *Aspergillus flavus* in field trials in India. Peanut Science.

Mixon, A.C. 1983. Aflatoxin resistant germplasm lines developed at Coastal Plain Station, Peanut Journal or Nut World 62 : 15 – 16.

Waliyar, F., Ba, A., Hassan, H., Bonkoungou, S. and Bosc, J.P. 1994. Sources of resistance to *Aspergillus flavus* and aflatoxin contamination in groundnut genotypes in West Africa, Plant Disease 78 : 704 – 708.

Zambettakis, C., Waliyar, F., Bockelee-Morvan, A.,and de Pinds, O. 1981. Results of four years' research on resistance of groundnut varieties to *Aspergillus flavus*. Olegineux 36 : 377 –385

Table 1. On-farm performance of aflatoxin resistant cultivars at Anantapur during 2003 and 2004.

Variety	2003 yield (Kg ha^{-1})		2004 yield (Kg ha^{-1})		Pooled (Kg ha^{-1})	
	Pod	Haulm	Pod	Haulm	Pod	Haulm
91278	419	1331	1245	2727	832	2029
91279	467	1431	1280	2532	874	1981
91283	575	917	1023	2365	799	1641
91284	536	1267	1418	2742	977	2005
91315	597	1768	1154	2467	876	2118
91317	383	1517	1182	2431	783	1974
91324	569	1275	1444	3067	1007	2171
91328	461	1602	1230	2536	846	2070
91341	567	1538	1118	2332	842	1936
92302	433	1053	1374	2769	904	1911
93305	439	1760	1386	2785	913	2272
93328	458	1355	1195	2375	827	1865
93379	686	1922	1315	2684	1001	2303
94434	583	2019	1445	2742	1015	2381
TMV-2	466	1333	1064	2357	765	1845
SEm	86.0	229.0	152.6	248.2	85.7	170.9

Table 2. On-farm performance of 14 varieties to *A. flavus* infection and aflatoxins contamination in Anantapur area during 2003 rainy season

VARIETY	*A. flavus* infection (%)			Aflatoxins (μg kg^{-1})			
	Bulk seed	Large seed	Small seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	7.5	3.5	NT	1.6	2.2	1.9	9.2
ICGV 91279	7.5	3.5	0.0	1.2	0.8	1.5	15.5
ICGV 91283	2.0	0.0	NT	0.6	0.8	1.0	8.8
ICGV 91284	0.0	3.0	1.5	1.5	2.3	1.7	10.8
ICGV 91315	1.0	5.0	7.0	0.7	2.5	0.9	7.5
ICGV 91317	3.0	0.5	NT	1.7	1.9	2.1	6.2
ICGV 91324	6.5	0.0	2.0	1.1	2.0	1.7	8.2
ICGV 91328	17.0	2.5	4.0	2.2	3.7	2.2	7.1
ICGV 91341	1.0	1.0	3.0	2.0	2.5	2.0	7.0
ICGV 92302	5.0	4.5	1.0	2.3	2.8	2.1	8.9
ICGV 93305	1.0	0.0	NT	2.1	1.6	1.8	13.1
ICGV 93328	1.5	0.0	NT	2.4	2.2	1.9	22.7
ICGV 93379	1.0	0.7	NT	1.9	2.7	2.7	1.9
ICGV 94434	0.5	3.0	1.0	1.9	4.1	2.7	7.1
TMV-2	3.0	2.0	5.0	1.3	1.0	90.5	6.7
SED	5.98	2.15	0.50	1.06	1.03	19.46	6.14
P value(Wald χ^2)	0.35	0.14	<0.001	0.90	0.16	0.03	0.56

NT= Not tested

Table 3. On-farm performance of 14 varieties to *A. flavus* infection and aflatoxins contamination in Anantpur area during 2004 rainy season.

VARIETY	*A. flavus* infection (%)		Aflatoxin (μg kg^{-1})			
	Bulk seed	Large seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	19.8	1.7	3.4	3.3	3.3	4.1
ICGV 91279	3.0	6.0	17.9	1.6	5.3	4.7
ICGV 91283	23.3	27.2	5.5	2.9	182.8	206.9
ICGV 91284	2.5	8.3	4.5	3.9	5.1	4.6
ICGV 91315	2.0	1.0	5.7	4.3	4.9	7.8
ICGV 91317	3.0	3.6	3.8	1.6	4.6	4.3
ICGV 91324	1.8	4.0	2.5	2.4	4.3	9.3
ICGV 91328	4.0	1.6	3.6	2.3	28.6	5.7
ICGV 91341	7.0	0.4	4.7	3.0	6.3	5.3
ICGV 92302	6.8	4.3	7.6	2.6	6.4	10.3
ICGV 93305	2.7	2.4	2.8	2.5	3.0	2.7
ICGV 93328	5.0	2.2	4.6	3.9	3.9	10.2
ICGV 93379	21.0	3.8	653.2	324.4	4.9	33.3
ICGV 94434	6.0	13.0	4.1	4.4	10.2	4.1
TMV-2	4.5	4.4	4.4	332.2	20.9	10.2
SED	7.20	5.40	1.64	165.90	48.27	71.78
P value(Wald χ^2)	0.07	<0.001	<0.001	0.58	0.11	0.63

Table 4. On- farm performance of farmers preferred aflatoxin resistant cultivars at Anantapur during 2003 and 2004 rainy seasons

Variety	2003 yield (Kg ha^{-1})		2004 yield (Kg ha^{-1})		Pooled (Kg ha^{-1})	
	Pod	Haulm	Pod	Haulm	Pod	Haulm
ICGV 91278	419	1331	1119	2377	769	1854
ICGV 91315	597	1768	1175	2474	886	2121
ICGV 91328	461	1602	1326	2710	894	2156
ICGV 93305	439	1756	1143	2349	791	2053
ICGV 93379	686	1922	1320	2605	1003	2263
ICGV 94434	583	2019	1238	1962	911	1995
TMV 2	466	133	1258	2814	862	2074
SEm	97.8	254.8	62.2	233.9	56.2	189.1

Table 5. On-farm performance of 6 selected varieties to *A. flavus* infection and aflatoxins contamination in Anantapur area during 2004 rainy season.

Variety	*A. flavus* inf. (%)		Aflatoxin (μg kg^{-1})			
	Bulk seed	Large seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	11.3	6.8	2.4	164.4	37.1	424.9
ICGV 91315	2.9	6.1	2.8	115.7	135.4	538.5
ICGV 91328	5.0	4.1	2.2	179.0	63.8	537.0
ICGV 93305	8.6	5.4	2.5	54.3	173.1	373.8
ICGV 93379	10.5	7.4	2.6	61.4	42.1	306.1
ICGV 94434	10.7	9.4	2.8	91.6	93.7	1020.5
TMV 2	0.0	4.0	0.0	5.9	160.6	4.8
SED	2.61	2.91	0.64	154.20	112.50	559.90
P value(Wald χ^2)	0.006	0.581	0.452	0.945	0.868	0.832

Table 6. On-farm performance of 14 varieties in one field (two villages) in Anantapur during 2004 rainy season. (Trial at Rekulakunta had 3 replications and west Narsapuram had one replication)

Variety	Rekulakunta		West Narsapurum		Pooled	
	Pod Yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Pod Yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Pod Yield (kg ha^{-1})	Haulm yield (kg ha^{-1})
ICGV 91278	703	1654	1483	3183	1093	2419
ICGV 91279	657	1598	1683	335	1170	2474
ICGV 91283	707	1376	1833	2800	1270	2088
ICGV 91284	732	1718	1500	3833	1116	2776
ICGV 91315	663	1635	1180	2478	922	2057
ICGV 91317	961	1872	1833	3350	1364	2611
ICGV 91324	814	1924	1675	4200	1245	3062
ICGV 91328	923	2197	1842	3317	1383	2757
ICGV 91341	706	1768	1967	3267	1337	2518
ICGV 92302	1048	2285	1917	3733	1483	3009
ICGV 93305	656	1698	1750	4033	1203	2866
ICGV 93328	435	1125	1733	3900	1084	2513
ICGV 93379	639	1608	1980	3858	1309	2733
ICGV 94434	637	1536	1520	3196	1079	2366
TMV 2	897	1924	1270	2950	1084	2437
SEm	23	24	*	*	135.5	272.3

* Single replication only

Table 7. On-farm performance of 14 varieties in one field (two villages) to *A. flavus* infection and aflatoxin contamination in Anantapur area during 2004 rainy season . (Trial at Rekulakunta had 3 replications and west Narsapuram had one replication)

VARIETY	West Narsapuram						Rekulakunta	
	A. flavus infection (%)		Aflatoxin (μg kg^{-1})				Bulk seed	
	Bulk seed	Large seed	Bulk seed	Large seed	Small seed	Damage seed	*A. flavus* inf (%)	Aflatoxin (μg kg^{-1})
ICGV 91278	4.0	0.0	616.9	0.0	4.4	15.9	5.3	2.2
ICGV 91279	0.0	0.0	0.0	22.1	2.3	14.8	19.0	1.1
ICGV 91283	28.0	18.0	3.2	0.0	3.9	2776.4	28.7	8.3
ICGV 91284	3.0	5.0	1.2	0.0	2.2	8.0	4.7	30.3
ICGV 91315	3.0	0.0	3.2	0.0	6.3	151.5	14.3	35.6
ICGV 91317	0.0	NT	2.0	2.8	5.2	1.7	4.0	0.8
ICGV 91324	0.0	0.0	2.3	0.0	2.5	8.6	8.0	0.0
ICGV 91328	14.0	2.0	87.0	1.4	1.1	6.2	21.3	215.3
ICGV 91341	0.0	4.0	2.4	0.0	4.0	3.5	10.0	1.6
ICGV 92302	4.0	1.0	2.1	0.0	0.0	NT	14.3	1.5
ICGV 93305	0.0	1.0	0.0	0.0	2.9	5.0	12.7	1.4
ICGV 93328	3.0	5.0	3.7	0.0	3.0	5.7	5.3	1.6
ICGV 93379	7.0	4.0	0.0	3.1	3.8	171.9	18.0	1.6
ICGV 94434	5.0	1.0	0.0	0.0	0.0	7.4	21.7	12.8
TMV-2	NT	0.0	NT	1.0	9.1	4.1	4.0	2.1
SED	*	*	*	*	*	*	6.25	75.53
F-probability	*	*	*	*	*	*	<0.001	0.46

* Single replication only

Table 8. On-station performance of aflatoxin resistant cultivars at ARS Anantapur during 2003 and 2004.

Variety	2003 yield (Kg ha^{-1})		2004 yield (Kg ha^{-1})		Pooled (Kg ha^{-1})	
	Pod	Haulm	Pod	Haulm	Pod	Haulm
ICGV 91278	441	937	1136	2430	789	1684
ICGV 91279	529	921	1112	2894	820	1908
ICGV 91283	561	416	983	1889	772	1152
ICGV 91284	641	681	1162	2588	901	1634
ICGV 91315	541	1093	1056	2455	798	1774
ICGV 91317	537	1323	1124	2609	830	1966
ICGV 91324	556	681	986	2210	771	1445
ICGV 91328	489	1002	1104	2649	796	1826
ICGV 91341	449	833	1002	2160	725	1496
ICGV 92302	585	697	1108	2335	846	1516
ICGV 93305	537	870	1226	2415	882	1693
ICGV 93328	433	841	1194	2394	813	1618
ICGV 94379	585	809	1130	2574	857	1692
ICGV 94434	474	1129	1117	2591	795	1860
TMV 2	585	213	1018	2280	801	1246
SEm	31.3	37.5	62.2	130.1	50.3	120.5

Table 9. On-station performance of 14 varieties to *A. flavus* infection and aflatoxin contamination at research station in Anantapur during 2003 and 2004 rainy season

Variety	2003							2004						
	Bulk seed		Large seed		Small seed		Damage seed	Bulk seed		Large seed		Small seed		Damage seed
	A.*flavus* inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	Aflatoxin (μg kg^{-1})
ICGV 91278	1.0	3.0	6.3	2.6	2.0	2.7	10.8	4.0	0.9	19.7	0.6	25.0	9.4	541.2
ICGV 91279	8.7	4.5	0.7	3.9	0.7	4.2	6.1	5.0	2.7	17.7	0.9	20.0	5.1	14.8
ICGV 91283	1.0	4.3	3.0	3.7	0.7	2.5	10.6	31.0	.09	15.3	1.4	23.5	120.1	9.3
ICGV 91284	5.3	3.7	3.3	3.6	0.0	5.0	8.8	3.3	1.9	28.7	0.7	12.2	5.9	119.3
ICGV 91315	0.0	4.4	0.7	2.9	0.7	3.1	6.4	5.7	3.3	7.0	1.3	10.0	13.0	9.2
ICGV 91317	1.3	4.4	0.7	2.6	0.0	2.9	8.1	2.3	2.1	7.3	3.0	7.8	7.1	382.9
ICGV 91324	0.0	3.3	0.7	2.3	0.0	4.7	6.5	11.7	1.4	11.7	16.9	10.0	5.7	15.4
ICGV 91328	0.7	5.3	3.0	1.5	1.3	5.2	10.2	10.7	1.3	19.0	1.0	29.3	5.9	7.8
ICGV 91341	1.0	4.6	3.7	1.9	1.0	5.2	11.0	14.3	14.2	19.7	0.8	27.0	6.5	NT
ICGV 92302	0.0	4.0	1.3	4.1	0.3	1.9	10.2	11.0	1.5	19.7	511.6	19.2	6.0	782.2
ICGV 93305	0.3	3.7	1.7	387.3	0.3	2.5	5.8	7.7	2.9	9.0	3.1	16.0	4.3	23.2
ICGV 93328	0.0	5.1	1.0	5.2	1.7	3.0	11.0	7.7	1.6	12.7	2.5	NT	5.8	16.3
ICGV 94379	1.3	4.1	0.0	4.3	0.7	2.3	9.6	10.3	145.8	6.0	1.2	12.7	4.5	23.9
ICGV 94434	0.0	2.9	0.7	4.4	1.3	1.7	7.1	13.3	1.1	13.0	1.2	NT	3.8	913.5
ICGV 89104	0.7	2.7	1.0	2.8	1.0	4.3	6.6							
TMV 2	1.3	3.4	0.0	3.9	0.3	3.9	3.6	12.0	6.7	3.3	0.0	3.3	3.3	16.5
K 134								27.0	3.0	9.3	0.0	6.9	3.2	10.7
SED	2.83	2.05	2.65	137.9	0.91	1.44	6.13	6.76	50.66	7.97	168.1	9.75	40.35	628.8
F-probability	0.238	0.974	0.640	0.511	0.595	0.226	0.992	0.009	0.479	0.201	0.360	0.050	0.474	0.673

Table 10. On-farm performance of aflatoxin resistant cultivars at Piler during 2003 and 2004.

Variety	2003 yield (Kg ha^{-1})		2004 yield (Kg ha^{-1})		Pooled (Kg ha^{-1})	
	Pod	Haulm	Pod	Haulm	Pod	Haulm
ICGV 91278	878	2340	1318	2889	1098	2615
ICGV 91279	1175	2684	1503	3047	1339	2866
ICGV 91283	744	1828	1106	2556	925	2192
ICGV 91284	1164	3028	1085	2453	1125	2740
ICGV 91315	953	2186	1428	2468	1190	2327
ICGV 91317	822	1897	1264	2883	1043	2390
ICGV 91324	925	2679	1149	2947	1036	2813
ICGV 91328	903	2022	1232	2706	1067	2364
ICGV 91341	533	1561	1921	4489	1227	3225
ICGV 92302	1003	2293	1007	2313	1005	2303
ICGV 93305	945	2412	1928	4244	1436	3328
ICGV 93328	758	1967	1486	3490	1127	2729
ICGV 93379	661	1710	1591	3847	1126	2779
ICGV 94434	1270	3363	1666	3760	1472	3562
TMV-2	892	2319	1664	3689	1277	3004
SEm	149.1	396.6	222.9	368.7	193.1	455.1

Table 11. On-farm performance of 14 varieties to *A. flavus* infection and aflatoxin contamination in Piler area during 2003 rainy season

VARIETY	*A.flavus* infection (%)			Aflatoxins (μg/kg)			
	Bulk seed	Large seed	Small seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	2.7	1.3	0.0	0.7	2.7	2.6	9.2
ICGV 91279	2.7	6.7	0.7	1.8	3.5	2.0	3.2
ICGV 91283	7.7	15.3	1.3	1.1	2.5	3.4	1.7
ICGV 91284	4.7	2.0	2.3	1.8	1.7	1.9	8.9
ICGV 91315	2.3	1.7	1.7	2.2	3.1	1.6	2.4
ICGV 91317	1.7	3.3	0.5	1.3	2.4	1.6	5.0
ICGV 91324	4.0	1.3	1.7	1.3	3.2	3.5	20.8
ICGV 91328	4.3	0.7	2.3	2.5	2.4	2.2	4.1
ICGV 91341	7.7	5.0	2.0	2.6	4.0	2.3	7.0
ICGV 92302	1.5	2.3	0.0	3.1	3.3	2.7	3.2
ICGV 93305	1.7	5.7	0.7	0.7	2.6	2.3	5.7
ICGV 93328	1.3	3.0	1.5	2.4	2.2	1.5	7.5
ICGV 93379	3.3	3.3	1.0	1.5	2.9	1.1	4.6
ICGV 94434	1.3	9.3	2.7	2.0	2.3	0.8	10.6
TMV-2	26.5	1.5	1.0	1.6	3.6	1900.0	61.1
SED	4.50	4.18	0.86	0.91	1.10	1.25	5.96
P value(Wald χ^2)	0.001	0.043	0.049	0.267	0.863	<0.001	<0.001

Table 12. On-farm performance of 14 varieties to *A. flavus* infection and aflatoxin contamination in Piler during 2004 rainy season (Mean of 6 replications)

Variety	*A. flavus* infection (%)		Aflatoxin (μg kg^{-1})			
	Bulk seed	Large seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	18.4	11.4	0.8	0.7	361.2	12.8
ICGV 91279	23.0	9.0	183.8	0.0	6.6	276.0
ICGV 91283	33.2	27.7	200.3	326.3	63.2	1349.4
ICGV 91284	16.2	2.7	57.6	0.3	5.8	76.5
ICGV 91315	13.6	10.5	125.4	275.9	39.6	1071.2
ICGV 91317	13.0	5.4	3.2	87.1	7.6	632.4
ICGV 91324	6.6	2.2	3.3	1.1	7.3	115.8
ICGV 91328	13.3	4.5	159.6	2.8	6.1	29.8
ICGV 91341	14.5	7.8	283.9	5.3	19.9	675.3
ICGV 92302	21.6	2.5	279.7	2.6	6.3	28.5
ICGV 93305	13.0	2.8	147.8	2.5	5.3	332.6
ICGV 93328	14.4	4.2	46.9	0.4	5.2	499.1
ICGV 93379	13.8	13.4	2.2	188.6	646.7	2243.3
ICGV 94434	11.8	4.9	4.9	0.8	7.7	418.7
TMV-2	32.0	2.8	262.0	2.0	0.6	5.0
SED	4.38	5.81	212.60	171.20	162.10	598.80
P value(Wald χ^2)	<0.001	0.001	0.963	0.627	0.001	0.008

Table 13. On-farm performance of farmers preferred aflatoxin resistant cultivars at Piler during 2003 and 2004.

Variety	2003 yield (Kg ha^{-1})		2004 yield (Kg ha^{-1})		Pooled (Kg ha^{-1})	
	Pod	Haulm	Pod	Haulm	Pod	Haulm
ICGV 91279	1175	2684	1908	4396	1542	3540
ICGV 91284	1181	3028	1628	3643	1404	3335
ICGV 91324	925	2678	1621	3643	1273	3161
ICGV 92302	1003	2259	1323	2759	1163	2509
ICGV 93305	945	2412	2148	4579	1546	3496
ICGV 93328	758	1967	2072	4392	1415	3180
ICGV 94434	1278	3363	2397	5063	1838	4213
TMV-2	892	2187	1722	4200	1307	3193
SEm	163.5	397.2	110.4	200.2	178.3	364.0

Table 14. On-farm performance of 7 selected varieties to *A. flavus* infection and aflatoxin contamination in Piler during 2004 rainy season (Mean of 9 replications)

Variety	*A. flavus* infection (%)		Aflatoxin ($\mu g\ kg^{-1}$)			
	Bulk seed	Large seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91279	12.8	2.8	273.5	1.8	25.1	136.0
ICGV 91284	14.3	3.3	2.3	16.3	3.6	23.8
ICGV 91324	10.6	5.3	2.5	1.2	2.0	332.0
ICGV 92302	7.6	3.0	163.7	2.6	107.7	17.8
ICGV 93305	10.6	4.4	338.9	1.5	43.8	272.0
ICGV 93328	9.0	6.9	184.2	1.4	3.2	262.2
ICGV 94434	10.0	8.3	383.0	1.1	3.2	403.4
TMV-2	NT	13.3	NT	154.8	0.0	13.4
SED	3.51	3.48	249.10	7.92	60.89	268.30
P value(Wald χ^2)	0.502	0.235	0.635	0.001	0.656	0.775

Table 15. On-farm performance of 14 varieties in one field (2 reps in one village) in Piler during 2004 rainy season

Variety	Pod ($kg\ ha^{-1}$)	Haulm ($kg\ ha^{-1}$)
ICGV 91278	1450	2758
ICGV 91279	1500	3508
ICGV 91283	909	2133
ICGV 91284	1166	2833
ICGV 91315	996	2533
ICGV 91317	1458	3458
ICGV 91324	1000	3000
ICGV 91328	1516	3500
ICGV 91341	2158	4333
ICGV 92302	1333	3250
ICGV 93305	1808	4342
ICGV 93328	1233	2767
ICGV 93379	2167	4525
ICGV 94434	1916	4434
SEm	215	561

Table 16. On-farm performance of 14 varieties in one field to *A. flavus* infection and aflatoxin contamination in Piler during 2004 rainy season. (Mean of 2 replications)

Variety	*A. flavus* infection (%)		Aflatoxin (μg kg^{-1})			
	Bulk seed	Large seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	31.0	8.0	1.5	0.0	1.2	906.9
ICGV 91279	9.0	18.0	5.7	348.5	2.4	72.5
ICGV 91283	24.0	41.0	7.5	0.5	21.9	1153.2
ICGV 91284	15.5	1.6	627.3	0.0	0.0	12.1
ICGV 91315	15.0	5.0	2.3	0.0	470.2	1133.5
ICGV 91317	5.0	4.0	5.1	0.0	0.9	1075.3
ICGV 91324	5.5	4.0	4.6	1.2	0.8	171.0
ICGV 91328	15.0	3.8	3.7	0.0	20.4	1037.5
ICGV 91341	17.5	7.0	254.9	59.6	782.3	1223.3
ICGV 92302	21.5	5.5	10.7	0.0	3.4	22.2
ICGV 93305	33.5	2.5	12.9	1.7	3.2	12.1
ICGV 93328	21.5	0.5	3.5	1.1	2.5	56.8
ICGV 93379	22.5	13.5	3.1	3.6	604.6	2075.4
ICGV 94434	32.0	2.5	0.8	0.0	1.6	35.5
SED	11.69	5.21	249.30	139.70	378.50	774.40
P value(Wald χ^2)	0.426	<0.001	0.470	0.370	0.441	0.412

Table 17. On-station performance of aflatoxin resistant cultivars at RARS, Tirupati during 2003 and 2004.

Variety	Pod yield (kg/ha)		
	2003	2004	Pooled
ICGV 91278	1941	1212	1577
ICGV 91279	1787	1118	1453
ICGV 91283	1628	807	1217
ICGV 91284	1920	1100	1510
ICGV 91315	1940	1036	1488
ICGV 91317	1692	910	1301
ICGV 91324	1811	1340	1575
ICGV 91328	1925	1111	1518
ICGV 91341	2047	1025	1536
ICGV 92302	2257	1292	1775
ICGV 93305	2350	1259	1804
ICGV 93328	2228	1240	1734
ICGV 93379	2222	1286	1754
ICGV 94434	2367	1309	1838
TMV-2	1561	920	1240
SEm	145.4	164.2	105.1

Table 18. On-station performance of 14 varieties to *A. flavus* infection and aflatoxin contamination at research station in Tirupati during 2003 and 2004 rainy seasons

Variety	2003							2004				
	Bulk seed		Large seed		Small seed		Damage seed	Large seed		Small seed		Damage seed
	A.flavus inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (μg kg^{-1})	Aflatoxin (μg kg^{-1})
ICGV 91278	2.3	1.0	3.7	0.0	1.3	1.8	8.8	2.0	1.5	2.3	4.3	56.2
ICGV 91279	1.3	1.5	0.0	0.5	0.7	1.1	9.5	2.0	1.2	9.5	4.9	37.2
ICGV 91283	8.7	1.5	7.0	0.0	1.7	1.3	10.0	2.3	0.6	1.7	4.8	27.3
ICGV 91284	0.7	0.9	0.0	0.0	1.3	3.2	9.7	0.0	1.9	4.0	3.9	21.0
ICGV 91315	1.0	1.3	2.0	0.5	1.7	2.4	10.8	NT	2.2	3.3	4.1	85.9
ICGV 91317	0.0	0.4	0.0	0.8	1.7	2.6	8.7	1.0	2.2	2.7	5.0	13.2
ICGV 91324	0.0	0.0	1.3	0.8	5.3	2.6	7.8	1.0	1.8	2.0	4.9	31.2
ICGV 91328	0.0	0.8	1.3	0.6	2.3	3.3	7.5	1.7	2.1	8.3	3.0	21.1
ICGV 91341	1.0	0.6	0.3	0.9	2.3	2.1	6.0	1.0	2.3	3.5	6.7	22.3
ICGV 92302	0.0	1.6	0.0	0.5	2.3	3.0	4.7	0.0	2.9	1.7	6.3	24.5
ICGV 93305	0.0	0.9	1.3	1.2	8.0	2.7	5.7	2.0	1.4	3.8	9.0	13.1
ICGV 93328	0.7	2.6	0.0	0.6	1.3	2.9	5.8	1.0	2.0	3.9	11.2	10.5
ICGV 94379	0.0	1.5	1.0	0.5	4.0	2.4	5.7	2.5	2.0	7.4	9.2	18.6
ICGV 94434	1.0	0.7	0.3	0.9	6.0	2.0	5.1	2.0	3.7	5.0	9.4	17.1
ICGV 89104	3.3	1.2	1.3	0.5	0.0	1.3	4.2					
TMV 2	1.0	1.2	0.3	0.4	2.3	1.6	8.2					
SED	2.71	0.92	2.89	0.74	2.56	1.50	3.20	0.93	1.59	3.28	3.76	31.03
F-probability	0.273	0.621	0.672	0.959	0.334	0.959	0.631	0.295	0.940	0.281	0.572	0.607

Table 19. On-farm performance of Aflatoxin tolerant cultivars at Mahabubnagar during 2003 rainy season

Variety	Pod yield (Kg ha^{-1})	Haulm yield (Kg ha^{-1})
ICGV 93379	236	584
ICGV 91278	216	545
ICGV 91317	192	504
ICGV 93305	125	315
ICGV 91283	133	327
ICGV 91341	103	267
ICGV 91284	140	364
ICGV 94434	123	320
ICGV 91328	180	437
ICGV 91324	161	371
ICGV 92302	574	1522
ICGV 91315	186	487
ICGV 93328	191	510
ICGV 91279	129	337
Local (TMV 2)	184	470
SEm	71.0	197.0

Table 20. On-farm performance of 14 varieties to *A. flavus* infection and aflatoxins contamination in Mahabubnagar area during 2003 rainy season

VARIETY	A. flavus infection (%)			Aflatoxins (μg kg^{-1})			
	Bulk seed	Large seed	Small seed	Bulk seed	Large seed	Small seed	Damage seed
ICGV 91278	11.5	5.0	9.0	2.8	2.8	1.7	8.7
ICGV 91279	4.3	1.7	9.0	2.6	2.1	1.8	2.6
ICGV 91283	1.0	1.5	0.5	1.8	2.4	0.7	4.6
ICGV 91284	1.3	1.3	3.0	1.7	1.3	1.3	2.7
ICGV 91315	4.0	1.7	2.7	3.6	1.8	0.3	5.2
ICGV 91317	5.7	0.3	3.0	3.8	2.7	2.0	6.9
ICGV 91324	2.0	6.0	3.0	2.9	1.9	1.1	5.8
ICGV 91328	2.0	2.0	0.5	2.7	2.3	5.0	5.6
ICGV 91341	3.7	1.7	20.5	2.9	3.1	2.2	1.5
ICGV 92302	3.0	0.7	3.3	2.8	1.7	0.5	2.8
ICGV 93305	1.5	2.5	NT	2.8	2.8	0.8	6.7
ICGV 93328	1.7	0.7	1.7	3.3	3.9	3.1	5.3
ICGV 93379	0.3	0.3	0.0	9.3	2.0	1.3	7.1
ICGV 94434	9.0	0.0	NT	6.7	0.0	1.2	1.0
TMV-2	3.0	2.0	2.0	5.3	5.2	39.2	46.4
SED	3.38	1.40	8.06	2.57	1.19	0.89	2.98
P value(Wald χ^2)	0.460	0.141	0.380	0.430	0.319	<0.001	<0.001

Table 21. On-farm *A.flavus* population in PVS trials at Piler and Anantapur during 2003 rainy season.

Variety	10^3 Cfu/gm of soil		
	Piler	Anantapur	Mahaboobnagar
ICGV 91278	2.5	1.7	5.6
ICGV 91279	2.1	1.2	2.1
ICGV 91283	3.0	2.0	3.4
ICGV 91284	4.0	0.7	1.1
ICGV 91315	2.3	1.1	1.1
ICGV 91317	3.1	1.6	3.4
ICGV 91324	2.8	2.0	1.3
ICGV 91328	2.6	0.9	2.0
ICGV 91341	6.7	1.3	1.4
ICGV 92302	4.0	1.8	5.7
ICGV 93305	2.0	0.9	3.2
ICGV 93328	1.8	2.2	1.2
ICGV 93379	5.9	2.3	2.5
ICGV 94434	4.0	1.4	1.9
TMV-2	4.9	1.4	2.4
SEm	1.62	0.49	1.22

Table 22. On-station *A. flavus* population at ARS, Anantapur and RARS Tirupati during 2003 rainy season

Variety	10^3 Cfu/gm of soil	
	Anantapur	Tirupati
ICGV 91278	2.9	2.0
ICGV 91279	1.8	2.0
ICGV 91283	2.1	2.8
ICGV 91284	2.3	2.3
ICGV 91315	2.1	2.4
ICGV 91317	2.2	2.1
ICGV 91324	1.6	2.0
ICGV 91328	1.7	1.9
ICGV 91341	2.7	3.1
ICGV 92302	1.2	2.6
ICGV 93305	7.5	2.8
ICGV 93328	2.0	2.2
ICGV 93379	3.5	2.0
ICGV 94434	1.7	2.7
TMV-2	2.0	2.7
SEm	0.70	0.38

Table 23. Occurrence of dry spells >14 d in Anantapur in 2003 and 2004

2003		2004	
Period	Duration (d)	Period	Duration (d)
09 June to 01 July	23	02 June to 08 July	37
16 to 31 July	16	30 July to 03 Sept.	36
24 Aug. to 25 Sept.	33	28 Oct. to 31 Dec.	65
25 Oct. to 31 Dec.	68		

Table 24. Farmer's preferred varieties in three districts in 2003 and 2004

	2003	2004	
District	Best	Best	Worst
Mahaboobnagar	ICGV 94434 ICGV 93305	Not grown	Not grown
Anantapur	ICGV 94434 ICGV 91278 ICGV 93305	ICGV 93379 ICGV 91278 ICGV 93328	ICGV 91283 ICGV 92302 ICGV 91315
Piler	ICGV 91279 ICGV 94434 ICGV 91284	ICGV 91341 ICGV 93305	ICGV 91283 ICGV 92302 ICGV 93328

Table 25. Varieties selected based on yield and PVS preference at Anantapur and Piler. Note: no discernable difference in aflatoxin contamination among cvs

Anantapur									
ARS 2003	ARS 2004	W. Narsap	Rekulakun	7 cv trial	*Not liked*	2003 PVS	2004 PVS	Selection	Seed colour
94379	94434	94379	92302	91328	*91283*	94434	94379	91278	White
1284	91324	92302	91328	94379	*92302*	91317	93328	94434	Red
	92302	91328			*91315*	91328	94434	91328	White
	94379	91317				91278		+TMV2	White
						93305			
Piler									
Tirupati 2003	Tirupati 2004	7 cv trial	14 cv trial		*Not liked*	2003 PVS	2004 PVS	Selection	Seed colour

94379	93305	94434	94379		*91283*	94434	91314	94379	Red
93305	91341	93328	91341		*93328*	93328	93305	94434	Red
94434	94434	93305	94434		*92302*	91324	91278	93305	Red
92302		91279	93305		*91315*	91279	94434	91341	Red
93328						91284		+91114	White
								+TMV2	White

Table 26. Strategies, approaches and action panel for the First Panel Meeting

S.No.	Issue	Approach	Action Plan
1	**Sensitive Communication Strategy - to** ▪ **Medical practitioners and nutritionists** ▪ **Decorticators, oil expellers and exporters** ▪ **Dissemination to farmers**	▪ Support existing Extension and Communication systems ▪ Provide Training to agrl extension staff ▪ Provide motivation and capacity building among NGOs agrl exten staff ▪ Generate Market demand for 'Low Afla Healthy / Quality Groundnuts'	▪ Develop communication strategies – (not to consumers at this stage). ▪ Consult Communication Experts / Consultants (NIRD) ▪ Seminars for Medical personnel by Dr.Raghunath Rao and Commissioner of Agril. to contact Commissioner of Family Welfare for the programs ▪ Awareness program for farmers by Oil Millers Assn ▪ Create Standards – SPS etc
2	**Appropriate Technology for Farmers**	▪ Provide Threshers, dryers, sprinklers, strippers, Tarpaulins, etc to farmers ▪ Provide Trichoderma (Spp), and other Biological control measures to farmers ▪ Introduce Low / No cost technologies and techniques among farmers	▪ Subsidies for threshers, etc ▪ Incorporate Panel recommendations through OPP programme of Agricultural Dept. ▪ Tarpaulins through AMCs / Marketing Dept on hire basis
3	**Create Policy on Aflatoxin control**	▪ Marketing strategies ▪ Regulatory mechanisms and ▪ Commodity standards-	▪ Come up with information as base material for creating policy
4	**Funding**	▪ Identify areas that require funding ▪ Identify funding sources	▪ Approach agencies for funding the action plans
5	**Increase Panel members**	▪ CFTRI, BIS, OTRI, AP Oil Millers Assn ▪ Dir Oil Seeds Devp	▪ Invite more stakeholders, specialists and other technical personnel as members
6	**Schedules for Follow-up on Action**		▪ Keep in constant contact for formalizing the actions ▪ Calendar of events to be undertaken for follow-up ▪ Next Panel Meeting – before harvest – Oct 04

Table 27. Action plan for the Second Panel Meeting

Target Group	Approach	Action Plan	Members
Consumers	▪ Sensitive and cautious approach	▪ Draft a consumer message that is sensitive to the impact on groundnut farmers' livelihood and does not create a panic situation and put up for discussion before adoption.	▪ Consortium of Andhra Pradesh Consumers Association
Farmers and Extension Personnel	▪ Tthrough technology transfer to and by government and NGO extension agencies.	▪ Train the extension personnel through projects & programs ▪ Regular Department training programs and demonstrations ▪ Setting up testing labs	▪ Dept of Agriculture, GoAP. ▪ ICRISAT ▪ NGOs
	▪ Training and Communication Materials	▪ Technical information and training material developed carefully keeping farmers requirements, feasibility and practicality at the field level in perspective	▪ Dept of Agriculture, GoAP. ▪ ICRISAT
	▪ Standards / Testing	▪ Establish number of testing facilities at convenient places	▪ Dept of Agriculture, GoAP. ▪ ICRISAT
Policy Makers	▪ Influence policy makers into establishing necessary parameters for regulating the levels of Aflatoxin and other mycotoxins into the food, feed and fodder chain	▪ A top and bottom approach ▪ Get the 'Prevention of Food Adulteration Act' suitably modified to include limits of mycotoxin residues	▪ Panel Secretariat and all members with linkages ▪ Dept of Agriculture, GoAP. ▪ ICRISAT

Table 28. An Overview of the Sources of Information Identified by Groundnut FarmersChittoor (Piler), Anantapur, Mahaboobnagar Districts of A.P.

Information Source	Piler			Anantapur			Mahaboobnagar		
	Rich Farmers	Poor Farmers	Women Farmers	Rich Farmers	Poor Farmers	Women Farmers	Rich Farmers	Poor Farmers	Women Farmers
Fore-fathers	✓	✓	✓	✓	✓	✓	✓	✓	✓
Co-farmers	✓	✓	✓	✓	✓	✓	✓	✓	✓
News papers	✓	✓		✓					
Radio	✓	✓	✓	✓			✓	✓	
Television	✓	✓	✓	✓	✓				
Journals	✓	✓							
Posters	✓	✓	✓						
Fertilizer and pesticide shops/ dealers	✓	✓		✓	✓	✓	✓	✓	✓
Oil Millers / Traders	✓	✓					✓	✓	✓
Agricultural Department	✓	✓	✓	✓	✓	✓	✓	✓	✓
NGO (Sahajeevan)	✓	✓	✓						
NGO (RDT)				✓	✓	✓			
Farmers' Agricultural Exhibition (Kissan mela)	✓	✓	✓	✓	✓	✓			
District level Farmers' meetings (Rythu Sadhassu – Govt Program)	✓	✓	✓	✓	✓	✓			
Farmers' Days (Rythu Dinothsavam - ANGRAU)	✓	✓	✓	✓	✓	✓			
Field Day -	✓	✓	✓	✓	✓	✓	✓	✓	✓
Janmabhoomi for agricultural programs (Govt. sponsored Peoples Participation Program)	✓	✓	✓	✓	✓	✓	✓	✓	✓

Table 29. On-farm management trial yield, *A.flavus* and aflatoxin at Rekulakunta village of Anantapur during 2004 rainy season

S No.	Treatment	Yield (Kg ha^{-1})		*A. flavus* inf. (%)	Aflatoxin (μg kg^{-1})		
		Pod	Haulm	Large seed	Large seed	Small seed	Damage seed
1	Application of farm yard manure @ 5 t/ha	1314	2303	3.9	0.3	0.6	3.4
2	Application of Trichoderma @ 150 kg ha^{-1}	1255	2234	2.9	0.3	0.7	6.8
3	Application of gypsum @ 500 kg ha^{-1}	1287	2311	3.8	0.4	0.8	11.7
4	Components 1 + 2 + 3	1384	2487	6.0	0.0	0.6	6.3
5	Farmers' practice (control)	1475	2624	4.8	0.0	1.1	8.9
	SED	63.7	99.9	1.72	0.17	0.35	4.19
	P value (Wald χ^2)			0.433	0.100	0.493	0.349

Table 30. On-station groundnut pod yield against different treatments of aflatoxin management trial at ICRISAT-patancheru center during 2003 rainy season

Treatments	Pod yield (kg ha^{-1})			
	Variety JL 24		Variety J 11	
	Control	Treatment application	Control	Treatment application
Compost	980.1	950.0	909.3	812.7
Cereal residue	1071.5	1131.5	1054.4	1195.4
Gypsum	1176.6	1083.5	1069.2	1147.2
Bio-control	937.5	929.2	763.9	874.8
Compost + Cereal residue	1055.6	919.0	1053.6	929.4
Compost + Gypsum	1168.8	978.5	1110.2	930.6
Compost +Bio-control	1161.6	1050.0	1242.8	1027.5
Cereal residue + Gypsum	993.5	973.1	1016.4	921.1
Cereal residue + Bio-control	1219.2	1030.8	982.9	906.0
Gypsum + Bio-control	1275.7	1081.0	1279.9	1192.6
Compost + Cereal residue + Gypsum	839.8	728.0	970.6	765.5
Compost + Cereal residue + Bio-control	790.0	781.9	846.8	746.8
Cereal residue + Bio-control + Gypsum	902.5	916.2	1060.2	936.3
Gypsum + Bio-control + Compost	1157.2	1008.6	1097.7	1084.0
Compost + Cereal residue + Gypsum + Bio-control	921.8	660.4	806.7	794.9
SEd (Treatment x Variety x Application) = 183.7 F-probability (Treatment x Variety x Application) = 0.669				

Table 31. *Aspergillus flavus* infection and aflatoxins contamination in bulk groundnut samples collected from on station trial at ICRISAT-Patancheru center during 2003 rainy season

Treatments	Variety JL 24				Variety J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavu* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	3.0	3	5.0	6	2.7	17	3.7	14
Cereal residue	1.0	2	1.7	17	2.3	4	0.7	16
Gypsum	2.7	6	2.7	448	1.3	7	0.7	5
Bio-control	0.7	7	3.0	5	1.0	4	1.0	27
Compost + Cereal residue	3.3	91	14.7	1	1.7	3	6.7	57
Compost + Gypsum	1.3	3	12.0	21	3.7	61	2.0	103
Compost + Bio-control	4.0	4	1.7	8	4.0	53	4.3	118
Cereal residue + Gypsum	0.3	3	2.7	4	0.3	5	0.7	3
Cereal residue + Bio-control	0.7	2	1.7	9	1.0	5	1.7	69
Gypsum + Bio-control	13.0	2	1.7	3	1.3	4	4.7	5
Compost + Cereal residue + Gypsum	1.0	22	1.7	7	1.3	0	2.3	5
Compost + Cereal residue + Bio-control	3.0	72	2.0	5	1.3	11	3.3	7
Cereal residue + Bio-control + Gypsum	0.7	133	2.0	208	1.3	1	0.3	6
Gypsum + Bio-control + Compost	11.7	454	8.7	10	0.7	14	2.7	146
Compost + Cereal residue + Gypsum + Bio-control	2.7	5	1.0	24	1.7	9	1.3	158

A. flavus infection: SED (Treatment x Variety x Application) = 4.05
and F-probability (Treatment x Variety x Application) = 0.319
Aflatoxin contamination: SED (Treatment x Variety x Application) = 129
and F-probability (Treatment x Variety x Application) = 0.362

Table 32. *Aspergillus flavus* infection and aflatoxins contamination in groundnut seed from large size pod collected from on station trial at ICRISAT-Patancheru center during 2003 rainy season

Treatments	Variety JL 24				Variety J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	0.0	4	6.0	34	1.3	6	7.0	103
Cereal residue	0.3	1	1.0	2	0.7	2	1.3	2
Gypsum	3.0	2	2.7	4	1.0	2	0.7	2
Bio-control	1.3	2	0.3	1	1.7	3	0.7	3
Compost + Cereal residue	0.3	2	3.0	10	0.7	8	0.7	3
Compost + Gypsum	1.3	1	1.3	5	1.0	1	1.0	2
Compost + Bio-control	3.0	0	1.7	0	1.0	0	4.3	386
Cereal residue + Gypsum	1.7	3	2.7	4	1.3	5	3.7	3
Cereal residue + Bio-control	0.0	1	3.3	0	0.3	0	2.3	0
Gypsum + Bio-control	0.7	2	1.0	2	0.7	1	1.3	2
Compost + Cereal residue + Gypsum	2.7	3	0.3	5	1.3	55	4.3	338
Compost + Cereal residue + Bio-control	2.0	1	4.0	2	6.7	355	1.7	3
Cereal residue + Bio-control + Gypsum	2.3	2	0.3	2	1.7	3	1.7	4
Gypsum + Bio-control + Compost	0.7	25	3.7	3	2.0	1	0.7	3
Compost + Cereal residue + Gypsum + Bio-control	3.7	2	7.0	184	0.0	2	2.0	2
A. flavus infection: SED (Treatment x Variety x Application) = 2.05 and F-probability (Treatment x Variety x Application) = 0.302 Aflatoxin contamination: SED (Treatment x Variety x Application) = 120.2 and F-probability (Treatment x Variety x Application) = 0.501								

Table 33. *Aspergillus flavus* infection and aflatoxins contamination in groundnut seed from medium size pod collected from on station trial at ICRISAT-Patancheru center during 2003 rainy season

Treatments	Variety JL 24				Variety J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	1.0	15	1.3	4	2.7	3	4.3	404
Cereal residue	4.0	3	2.7	47	1.3	5	0.0	3
Gypsum	2.0	2	2.3	3	0.7	2	0.7	4
Bio-control	6.0	157	3.0	6	3.7	5	1.0	5
Compost + Cereal residue	0.3	2	0.7	4	0.7	1	2.0	2
Compost + Gypsum	2.0	1	3.3	23	0.0	1	2.3	3
Compost + Bio-control	0.7	3	3.0	4	0.0	5	2.0	3
Cereal residue + Gypsum	1.7	3	1.7	3	2.3	3	1.3	2
Cereal residue + Bio-control	1.0	2	1.7	4	0.3	6	4.0	3
Gypsum + Bio-control	2.3	3	1.0	1	0.3	2	1.7	2
Compost + Cereal residue + Gypsum	1.3	2	1.7	4	0.7	2	4.0	407
Compost + Cereal residue + Bio-control	3.0	4	0.3	21	2.7	16	0.7	6
Cereal residue + Bio-control + Gypsum	2.0	2	1.0	2	2.3	4	1.0	2
Gypsum + Bio-control + Compost	3.3	270	3.0	3	3.0	1080	1.3	59
Compost + Cereal residue + Gypsum + Bio-control	3.7	5	2.0	6	4.7	3	1.7	4

A. flavus infection: SED (Treatment x Variety x Application) = 1.93
and F-probability (Treatment x Variety x Application) = 0.987
Aflatoxin contamination: SED (Treatment x Variety x Application) = 230.1
and F-probability (Treatment x Variety x Application) = 0.485

Table 34. *Aspergillus flavus* infection and aflatoxins contamination in groundnut seed from small size pod collected from on station trial at ICRISAT-Patancheru center during 2003 rainy season

Treatments	Variety JL 24				Varity J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	1.7	1064	6.7	10	1.3	6	4.3	13
Cereal residue	4.7	4	1.3	3	0.0	5	8.0	257
Gypsum	2.3	9	1.7	7	2.3	9	1.7	8
Bio-control	1.7	5	11.7	5	1.3	6	11.3	5
Compost + Cereal residue	2.3	240	6.3	6	0.7	9	2.0	20
Compost + Gypsum	2.0	6	5.0	20	1.0	12	11.3	7
Compost + Bio-control	0.7	6	1.7	4	1.3	8	0.3	7
Cereal residue + Gypsum	4.3	5	5.0	7	1.7	8	3.3	7
Cereal residue + Bio-control	2.7	16	1.0	7	4.0	5	1.7	5
Gypsum + Bio-control	10.0	212	4.0	7	1.0	8	5.0	6
Compost + Cereal residue + Gypsum	2.3	4	5.0	170	2.0	4	6.0	7
Compost + Cereal residue + Bio-control	16.0	18	2.3	10	5.0	150	3.3	12
Cereal residue + Bio-control + Gypsum	2.3	9	1.7	5	2.0	5	4.3	14
Gypsum + Bio-control + Compost	1.7	5	5.0	202	1.3	5	7.7	8
Compost + Cereal residue + Gypsum + Bio-control	3.0	7	3.3	6	3.0	7	3.7	6
A. flavus infection: SED (Treatment x Variety x Application) = 4.26 and F-probability (Treatment x Variety x Application) = 0.220 Aflatoxin contamination: SED (Treatment x Variety x Application) = 128.2 and F-probability (Treatment x Variety x Application) = 0.004								

Table 35. Aflatoxins contamination in groundnut seed from damaged pod during in on-station trial at ICRISAT center during 2003 rainy season

Treatments	Aflatoxin (ug kg^{-1})			
	Control		Treatment appl.	
	JL 24	J 11	JL 24	J 11
Compost	44	807	21	1266
Cereal residue	15	32	419	11
Gypsum	977	26	56	13
Bio-control	288	239	16	15
Compost + Cereal residue	10	385	900	445
Compost + Gypsum	202	26	1456	983
Compost +Bio-control	45	40	661	77
Cereal residue + Gypsum	934	183	127	29
Cereal residue + Bio-control	37	378	884	14
Gypsum + Bio-control	466	520	81	43
Compost + Cereal residue + Gypsum	88	14	152	25
Compost + Cereal residue + Bio-control	853	525	58	10
Cereal residue + Bio-control + Gypsum	23	84	19	21
Gypsum + Bio-control + Compost	334	959	423	230
Compost + Cereal residue + Gypsum + Bio-control	424	916	12	826
Aflatoxin contamination: SED (Treatment x Variety x Application) = 551 and F-probability (Treatment x Variety x Application) = 0.772				

Table 36. Groundnut pod yield against different treatments of aflatoxins management on-station trial at ICRISAT-Patancheru center during 2004 rainy season

Treatments	Pod yield (kg ha^{-1})			
	Variety JL 24		Variety J 11	
	Control	Treatment application	Control	Treatment application
Compost	1784	1453	1613	1412
Cereal residue	1545	1511	1511	1410
Gypsum	1684	1337	1337	1440
Bio-control	1838	1230	1230	1389
Compost + Cereal residue	1837	1422	1422	1363
Compost + Gypsum	1724	1347	1347	1003
Compost +Bio-control	1432	1359	1359	1256
Cereal residue + Gypsum	1729	1408	1408	1430
Cereal residue + Bio-control	1653	1604	1604	1468
Gypsum + Bio-control	1520	1570	1570	1431
Compost + Cereal residue + Gypsum	1591	1334	1334	1231
Compost + Cereal residue + Bio-control	1694	1509	1509	1395
Cereal residue + Bio-control + Gypsum	1502	1371	1371	1516
Gypsum + Bio-control + Compost	1693	1364	1364	1232
Compost + Cereal residue + Gypsum + Bio-control	1569	1325	1325	1569
SED (Treatment x Variety x Application) = 246.6 and F-probability (Treatment x Variety x Application) = 0.490				

Table 37. *Aspergillus flavus* infection and aflatoxins contamination in bulk groundnut samples collected from on station trail at ICRISAT-Patancheru center during 2004 rainy season

Treatments	Variety JL 24				Variety J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavu* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	1.0	154	1. 0	284	1.3	146	1.0	256
Cereal residue	0.0	829	1.3	499	0.0	5	0.3	18
Gypsum	0.3	788	1.7	697	1.3	4	0.0	374
Bio-control	1.3	4	1.7	24	1.0	12	1.3	117
Compost + Cereal residue	2.7	13	4.7	629	0.3	72	0.7	4
Compost + Gypsum	0.0	1	2.0	141	1.0	2	2.7	18
Compost + Bio-control	3.0	5	3.0	551	0.0	17	1.7	946
Cereal residue + Gypsum	1.3	142	1.0	1342	3.0	522	1.0	385
Cereal residue + Bio-control	2.7	31	0.7	25	1.3	3	1.3	9
Gypsum + Bio-control	2.0	390	1.3	36	2.0	226	1.7	145
Compost + Cereal residue + Gypsum	1.0	7	0.7	3	1.7	2471	1.3	36
Compost + Cereal residue + Bio-control	1.3	98	1.3	298	1.7	12	2.0	575
Cereal residue + Bio-control + Gypsum	1.7	161	1.0	479	0.3	11	0.3	219
Gypsum + Bio-control + Compost	0.7	69	0.3	1495	1.3	1509	0.7	8
Compost + Cereal residue + Gypsum + Bio-control	1.0	6	2.3	686	1.0	286	1.0	301

A. flavus infection: SED (Treatment x Variety x Application) = 1.37
and F-probability (Treatment x Variety x Application) = 0.951
Aflatoxin contamination: SED (Treatment x Variety x Application) = 629.4
and F-probability (Treatment x Variety x Application) = 0.248

Table 38. *Aspergillus flavus* infection and aflatoxins contamination in groundnut seed from large size pod collected from on station trial at ICRISAT-Patancheru center during 2004 rainy season

Treatments	Variety JL 24				Variety J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	0.3	4	0.7	34	0.0	9	0.0	5
Cereal residue	0.0	73	0.7	3	0.7	5	0.7	2
Gypsum	0.3	3	1.0	1454	1.0	9	1.0	4
Bio-control	2.7	5	2.0	547	1.3	7	1.3	6
Compost + Cereal residue	1.0	4	0.3	4	0.7	5	1.3	232
Compost + Gypsum	1.0	1	0.0	3	0.7	3	0.7	30
Compost + Bio-control	1.7	2	0.7	2	0.7	4	0.3	1
Cereal residue + Gypsum	2.0	5	2.0	3	3.7	5	1.0	4
Cereal residue + Bio-control	0.0	1015	0.7	382	0.7	2	0.7	5
Gypsum + Bio-control	1.7	588	1.7	7	4.7	6	2.7	12
Compost + Cereal residue + Gypsum	4.7	6	0.7	4	2.0	3	1.3	4
Compost + Cereal residue + Bio-control	0.00	0	0.3	2	2.0	20	0.3	131
Cereal residue + Bio-control + Gypsum	0.0	4	0.7	2	0.7	5	0.7	4
Gypsum + Bio-control + Compost	5.7	4	0.3	6	0.3	5	0.0	10
Compost + Cereal residue + Gypsum + Bio-control	0.0	7	0.0	5	2.3	151	0.3	5

A. flavus infection: SED (Treatment x Variety x Application) = 1.75
and F-probability (Treatment x Variety x Application) = 0.573
Aflatoxin contamination: SED (Treatment x Variety x Application) = 357.3
and F-probability (Treatment x Variety x Application) = 0.598

Table 39. *Aspergillus flavus* infection and aflatoxins contamination in groundnut seed from medium size pod collected from on station trial at ICRISAT-Patancheru center during 2004 rainy season

Treatments	Variety JL 24				Variety J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	1.0	5	0.7	2	1.0	4	1.0	15
Cereal residue	0.0	98	0.3	68	2.0	2	0.0	1
Gypsum	0.3	2	0.3	789	0.3	702	0.7	6
Bio-control	2.0	10	0.7	60	0.0	3	1.0	4
Compost + Cereal residue	5.3	7	3.0	340	1.7	3	1.7	63
Compost + Gypsum	0.7	2	2.0	8	1.0	1	1.3	5
Compost + Bio-control	2.7	365	0.0	7	0.7	8	1.7	56
Cereal residue + Gypsum	3.7	11	2.0	4	2.7	5	3.7	1572
Cereal residue + Bio-control	1.0	495	1.0	3	1.7	2	3.0	2
Gypsum + Bio-control	0.7	708	0.0	6	2.3	358	0.0	201
Compost + Cereal residue + Gypsum	1.3	2	0.7	2	1.3	3	0.7	2
Compost + Cereal residue + Bio-control	3.3	948	0.7	5	1.0	0	6.0	0
Cereal residue + Bio-control + Gypsum	0.33	3	1.3	1	5.0	506	0.0	11
Gypsum + Bio-control + Compost	4.7	70	1.0	1	1.3	462	1.3	6
Compost + Cereal residue + Gypsum + Bio-control	1.0	2815	0.3	15	2.7	168	0.0	9

A. flavus infection: SED (Treatment x Variety x Application) = 2.15
and F-probability (Treatment x Variety x Application) = 0.230
Aflatoxin contamination: SED (Treatment x Variety x Application) = 660.6
and F-probability (Treatment x Variety x Application) = 0.443

Table 40. *Aspergillus flavus* infection and aflatoxins contamination in groundnut seed from small size pod collected from on station trial at ICRISAT-Patancheru center during 2004 rainy season

Treatments	Variety JL 24				Varity J 11			
	Control		Treatment appl.		Control		Treatment appl.	
	A.flavus inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})	*A.flavus* inf.(%)	Aflatoxin (ug kg^{-1})
Compost	2.0	11	5.7	737	3.7	469	1.3	75
Cereal residue	0.7	45	1.0	20	0.7	5	1.3	3
Gypsum	1.0	47	2.3	10	0.3	14	5.3	52
Bio-control	1.3	6	9.0	5	0.0	98	2.7	14
Compost + Cereal residue	0.3	6	4.3	560	1.3	6	10.3	304
Compost + Gypsum	0.3	5	3.3	265	1.3	22	3.0	6
Compost + Bio-control	0.0	1	3.3	102	2.3	3	2.0	25
Cereal residue + Gypsum	4.3	76	3.0	8	9.0	757	2.7	1300
Cereal residue + Bio-control	0.3	735	1.3	5	0.7	7	2.0	333
Gypsum + Bio-control	2.7	6	2.3	6	3.7	49	1.3	19
Compost + Cereal residue + Gypsum	11.7	168	4.0	379	2.0	3	3.0	23
Compost + Cereal residue + Bio-control	0.3	38	2.3	28	3.7	431	0.0	5
Cereal residue + Bio-control + Gypsum	19.0	5	2.7	16	1.3	86	2.0	5
Gypsum + Bio-control + Compost	2.3	387	1.0	30	1.0	957	1.3	7
Compost + Cereal residue + Gypsum + Bio-control	0.0	8	0.7	24	3.3	3	2.0	24

A. flavus infection: SED (Treatment x Variety x Application) = 4.19
and F-probability (Treatment x Variety x Application) = 0.330
Aflatoxin contamination: SED (Treatment x Variety x Application) = 358.8
and F-probability (Treatment x Variety x Application) = 0.486

Table 41. Aflatoxins contamination in groundnut seed from damaged pod in on-station trial at ICRISAT center during 2004 rainy season

Treatments	Aflatoxin (ug kg^{-1})			
	Control		Treatment appl.	
	JL 24	J 11	JL 24	J 11
Compost	1841	1761	3572	1511
Cereal residue	755	951	845	1023
Gypsum	1639	1447	131	2347
Bio-control	563	1541	1187	1467
Compost + Cereal residue	531	3297	1030	1611
Compost + Gypsum	1662	339	1082	2623
Compost +Bio-control	1227	2833	471	1215
Cereal residue + Gypsum	2242	2099	1702	123
Cereal residue + Bio-control	701	2172	2647	2686
Gypsum + Bio-control	2482	1299	163	2276
Compost + Cereal residue + Gypsum	2248	3151	2480	170
Compost + Cereal residue + Bio-control	15	557	1686	550
Cereal residue + Bio-control + Gypsum	1759	948	104	150
Gypsum + Bio-control + Compost	1579	815	105	1357
Compost + Cereal residue + Gypsum + Bio-control	350	2426	2155	5323
Aflatoxin contamination: SED (Treatment x Variety x Application) = 1376.8 and F-probability (Treatment x Variety x Application) = 0.189				