On-farm Evaluation of Cultural Practices for Management of Aflatoxins in Groundnut

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Abstract

Integrated management practice schedule was evaluated with farmers' participation to prevent pre-harvest aflatoxin contamination. A total of 25 trials were conducted in different villages of Junagadh and Amreli districts of Gujarat in 2004. The farmers practice (FP) comprised of all agronomic practices such as seed (120 kg/ha), spacing (60 cm row to row and 15 cm plant to plant), fertilizers (12 kg N, 25 kg P_2O_5), weeding (two at 20 and 30-35 days after sowing), interculturing (one) and final harvest. Besides these FP, the integrated management practice (IP) additionally included summer ploughing, seed treatment with carbendazim 50 WP (2 g/kg), furrow application of castor cake enriched with *Trichoderma* (2.5 kg in 50 kg) at sowing, application of gypsum (500 kg/ha) at flowering, spray applications of neem oil (2%) at 45 days after sowing (DAS) and then carbendazim (0.05%) plus mancozeb (0.2%) at 60-70 DAS, harvest at 75% pod maturity and removal of damaged pods. The IP was effective in reducing the soil population of *A. flavus*, seed infection and colonization and the aflatoxin contamination in comparison with FP. The yield was also significantly high in IP adopted plots with an incremental cost benefit ratio (ICBR) of 1.68. Surveys conducted subsequently during 2006 revealed that only a few farmers (<10%) were adopting the technology that too only a few components such as seed treatment, application of *Trichoderma* or application of castor cake. The farmers perceived the good quality groundnut as fully formed big, bold and spotless pods with high oil content and high shelling out-turn. Neither farmers nor groundnut traders were aware of the problem of aflatoxins contamination of the produce and therefore, did not consider aflatoxins as a quality criterion. The IP necessitated about 25% higher cost on expenditure but the aflatoxin-free groundnut thus produced did not fetch any premium price in the market. Based on the studies, it is concluded that adoption of technology depended on the timely availability of inputs, creating awareness on the ill effects of aflatoxins and providing a premium price for aflatoxin-free groundnut.

Key words: Groundnut, *Aspergillus flavus*, aflatoxins, integrated management, on-farm evaluation

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Aflatoxins are naturally occurring fungal toxins produced mainly by *Aspergillus flavus* and *A. parasiticus*, and are most potent hepatocarcinogens causing serious food quality and safety issues worldwide. The export of groundnuts from India is affected due to the presence of aflatoxins. Aflatoxin contamination of groundnut can occur at any stage from harvest to consumption (Freeman et al 1999). The quality of the produce depends on the careful pre-harvest crop husbandry and optimization of post-harvest conditions of groundnut produce to avoid aflatoxin contamination. To prevent pre-harvest aflatoxin contamination, an integrated management practice was developed at National Research Centre for Groundnut (NRCG), Junagadh, which was evaluated on-farm with farmers' participation in Junagadh and Amreli district of Gujarat in 2004. Later, the level of adoption was assessed during 2006. Farmer participatory approach helps in designing more effective linkages between the scientists and farmers for technology assessment and refinement. Solutions oriented towards felt-needs of farmers have greater potential for adoption and for achieving desirable changes particularly creating mass awareness about the ill effects of aflatoxins and the adoption of management practices to mitigate this problem.

Materials and Methods

Twenty-five on-farm trials were conducted in different villages of Junagadh and Amreli in 2004. The integrated management practice (IP) was compared with farmers' practices (FP). FP comprised of all agronomic practices viz, seed (120 kg/ha), spacing (60 cm row to row and 15 cm plant to plant), fertilizers (12 kg N, 25 kg P_2O_5), weeding (two at 20 and 30-35 days after sowing), interculturing (one) and harvest. Additionally, IP included summer ploughing, seed treatment with carbendazim 50 WP (2 g/kg seed), furrow application of castor cake enriched with *Trichoderma harzianum* (*NRCG T-170*) @ 2.5 kg mixed with 50 kg castor cake/ha at sowing, application of gypsum (500 kg/ha) at flowering, one spray of neem oil (2%) at 40-45 days after sowing (DAS) followed by a spray of carbendazim (0.05%) plus mancozeb (0.2%) at 60-70 DAS, harvest at 75% pods maturity and removal of damaged pods. Each treatment was replicated twice with a plot size of 1000 m^2. Groundnut cv. GG-20 was used and the crop was raised in kharif under rainfed conditions. Soil samples (up to 10 cm depth) were collected at sowing and pod development stages from five random spots from between plants and pooled for each plot. The soil population of *A. flavus* was estimated using *A. flavus* and *A. parasiticus* agar (AFPA) medium by dilution plating (Horn and Dorner 1998). At harvest, pods were collected from three random spots in each plot. The level of seed infection and the colonization by *A. flavus* were recorded after seed plating on to moistened filter paper in sterilized Petri dishes (9 cm diam.) and incubated for 7 d at 28±1C. The level of aflatoxin contamination in seed was analyzed through indirect competitive ELISA as described by Ajitkumar et al (2004).

To assess knowledge and the level of adoption of the IP, surveys were conducted during 2006 in the selected villages at five at Visavdar, Talala, Kesod, Vanthali and Veraval talukas in Junagadh, and at Rajula, Bagesara, Dhari, Manekwada and Movia talukas in Amreli. Two villages were covered in each taluka. The data on level of adoption was collected with the help of questionaire, which consisted of statements pertaining to cultural practices for aflatoxin management by personal interview of farmers and group discussions. The knowledge test consisted of thirty-two statements, the relevancy of which was earlier ascertained by experts from Junagadh Agricultural University, Junagadh, NRCG and the Gujarat State Agriculture Department. The significance of the means of FP and IP were compared by *t* test.

Results and Discussion

Population of *A. flavus*. The results of the on-farm trials showed that the IP was effective in reducing soil population of *A. flavus*. In 15 of 25 trials, a reduction in soil population of *A. flavus* at pod development stage was observed. The populations ranged from 0.8 to 7.4 x 10^3 as compared to 3.6 to 17.0 x 10^3 cfu/g soil in FP (Table 1). About 52% sample from IP plots had population of *A. flavus* at ≤ 2 x 10^3 cfu/g soil. The low soil population of *A. flavus* in IP plots may be attributed to use of biocontrol agent, *Trichoderma* and application of castor cake. It was also observed that despite similar population levels in all field soils at sowing, plots adopted to IP had low populations of *A. flavus* in soils at pod development stage compared to plots treated with FP.

Seed infection and colonization. From the on-farm trials, it was evident that the seed infection and colonization was reduced in IP plots. Low levels of seed infection and seed colonization were observed in 16 IP plots as compared to FP plots (Table1).

Table 1. Soil population of *Aspergillus flavus*, seed infection and colonization and the aflatoxins contamination in integrated management practice (IP) and farmers' practice (FP)

Parameters	IP plots	FP plots	Remarks
Soil population of *A. flavus* (cfu/g soil)			
At sowing	0.33-2.67 x 10^3	0.33-2.75 x 10^3	-
At pod development stage	0.8-7.4 x 10^3	3.6-17.0 x 10^3	Reduction in 15 IP plots out of 25
Sample with population ≤ 2 x 10^3 cfu/g soil (%)	52	0	-
Seed infection (%)	0-8	6-42	Reduction in 16 IP plots out of 25
Sample having zero seed infection (%)	64	8	-
Seed colonization (%)	0-4	0-33	Reduction in 16 IP plots out of 25
Sample having zero seed colonization (%)	52	28	-
Level of aflatoxin B_1 (µg/kg)	0.87-29.18	4.37-1132.71	Reduction in 18 IP plots out of 25
Sample with aflatoxin B_1 ≤ 2 µg/kg (%)	48	0	-

There was no seed infection in 64% of samples from plots treated with IP; seed colonization was absent in 52% of samples from IP plots. The low infection in plots treated with IP could be attributed to inhibition of *A. flavus* population by seed treatment with systemic fungicide, soil application of *Trichoderma* and reduced biotic stresses due to diseases (leaf spots and rust) and pests. Plants undergoing biotic stresses are more susceptible to *A. flavus* infection and aflatoxin contamination. Reddy (2000) reported that late leaf spot management reduced the aflatoxin content. The application of gypsum provides sufficient calcium to the plant and offers tolerance to invasion of *A. flavus* (Reddy et al 2003).

Level of aflatoxin contamination. A reduction in the level of aflatoxin contamination was observed in 18 IP plots. Forty-eight percent of seed samples from IP plots had aflatoxin B_1 at ≤2 µg/kg. In contrast, aflatoxin in seed samples from FP plots was detected at ≥4 to 1133 µg/kg (Table 1). Such striking difference in seeds from FP and IP plots may be attributed to absence of stress to plants at pod filling stage due to optimum crop husbandry in the IP adopted plots.

Economics of IP and FP. The cost of production included cost of seeds, fertilizers, gypsum, castor cake, *Trichoderma* and pesticides besides the charges for various operations like land preparation, sowing, weeding, inter-culturing and harvesting (Table 2). The major input cost components in cultivation were seed (27-33%) and labour (23-25%). The data of the trials revealed that though IP involved about 24% higher cost of cultivation, it also gave higher pod (30%) and haulm yields (24%). The gross monetary return and net monetary return in plots adopted to IP were 29% and 33% higher, respectively (Fig. 1). pots and rust diseases, and incidence of insect pests.

Table 2. Yield and economics of integrated management practice (IP) over farmers' practice (FP)

Treatment	Pod yield (kg/ha)*	Haulm yield (kg/ha)*	ICBR
Integrated management practice	1985	3630	1.68
Farmers' practice	1524	2928	
CD *(P=0.05)*	82.04	113.85	
$t_{(cal)}$ at 23df	12.46**	23.98**	

*Average of trials conducted in 2004; ** (*P=0.01*)

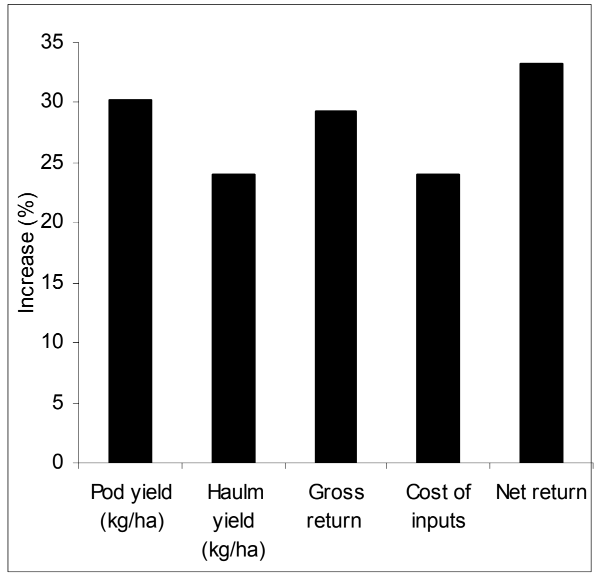

Figure 1. Increases in yield and monetary returns from adoption of integrated practices over that of farmers practices in the cultivation of groundnut in Junagadh, Gujarat, India

On the basis of analysis of pooled data of on-farm trials an incremental cost benefit ratio (ICBR) of 1.68 was realized in IP. Higher pod and haulm yields in plots adopted to IP than FP was due to optimum crop husbandry besides the low biotic stress due to leaf spots and rust diseases, and incidence of insect pests.

Level of knowledge, extent of adoption and quality perception. It was found that irrespective of the size of holding and literacy levels the knowledge on aflatoxins was very low among the farmers. About 90% farmers had not heard of aflatoxins. Kumar and Popat (2007) had also reported a low awareness about aflatoxin contamination of groundnut among the farmers of Junagadh. However, it was found that a few farmers who still adopted the IP technology were using only some of the components such as seed treatment, application of *Trichoderma* or application of castor cake. Discussions with farmers also revealed that the IP involved about 25% additional costs. Further, the aflatoxin-free groundnut thus produced with IP did not fetch any premium price in the market.

Farmers were concerned more about good quality seed material and good marketable produce rather than aflatoxins contamination of their produce. Their perceptions of good quality were based on the extent of fully formed big, bold and spotless pods, shelling out-turn and the kernel oil content. Further group discussions with farmers clearly indicated that they were neither aware of aflatoxins contamination nor had any means to identify and detect the same.

The results demonstrated that simple crop management practices could significantly reduce aflatoxin contamination at the production level. The adoption of technology was, however, low. The discussions with the farmers revealed that for large-scale adoption of IP, the lack of timely availability of the inputs like *Trichoderma*, castor cake and the availability of labour during the peak season were the major constraints. Farmers were of the opinion that application of enriched *Trichoderma,* as furrow application was cumbersome. The reason for non-adoption also included the fact that they were never asked to check or verify the aflatoxin contamination in their produce. None of the marketing channels where they generally disposed their produce had any restrictions on the sale of aflatoxin-contaminated groundnut. Farmers did not get any premium price for aflatoxin-free groundnut in the market.

Conclusions. Though the on-farm trials demonstrated the efficacy of an integrated management to reduce aflatoxin contamination in groundnut at the production level, the adoption of technology will continue to remain low unless a series of interventions take place that give the incentives to farmers. Farmers work under several socioeconomic constraints, which are likely to become their primary concern before they change their current management practices. Therefore, for a widespread adoption of IP in groundnut production technology, it is suggested that an awareness campaign about the ill effects of aflatoxins be undertaken for producers, marketing personnel and exporters

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