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POST HARVEST PROGRAMME IN ICRISAT[1]

by

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Introduction

The basic role of ICRISAT is to serve the small farmer of the Semi-Arid Tropics (SAT). The four main objectives of the research program are:

1. To serve as a world centre to improve the genetic potential for grain yield and nutritional quality of sorghum, pearl millet, pigeonpea, chickpea, and groundnut.

2. To develop farming systems which will help to increase and stabilise agricultural production through better use of natural and human resources in the seasonally dry semi-arid tropics.

3. To identify socio-economic and other constraints to agricultural development in the semi-arid tropics and to evaluate alternative means of alleviating them through technological and institutional changes.

4. To assist national and regional research programs through cooperation and support and to contribute further by sponsoring conferences, operating international training programs, and assisting extension activities.

For the comprehensive nature of these objectives it is clear that post harvest problems fall within the mandate of ICRISAT. However, many of the important storage problems of SAT crops are already being handled by specialised institutes, and this, and the pressing nature of the many field problems affecting the crops has led to the present relatively low priority being given to research on post harvest problems.

In this paper brief mention will be made of a storage pest problem that has received attention at ICRISAT, and of a socio-economic investigation of the impact of machine threshing of cereals in an Indian SAT village. Most of the paper will be devoted to research at ICRISAT on the problem of aflatoxin contamination of groundnuts, a very serious problem in all parts of the world where the crop is grown, and one which has important post harvest and storage components.

Bruchid Infestation of Stored Pigeonpea and Chickpea Seeds

Callosobruchus spp are found as appreciable infestations of mature pigeonpea pods when the crop is in the field, but examination of numerous samples of chickpea pods from India and other countries indicates that infestation with these insects is a purely post harvest phenomenon.

In cooperation with ICRISAT scientists, Professor Ernst K Horber of Kansas State University, USA, has been studying the chemistry involved in the differences in susceptibility to bruchids found in pulse seeds. Substantial differences in susceptibility have been found among the germplasm lines tested.

Several vegetable oils have been tested for the protection of pigeonpea and chickpea seeds from bruchid attack and the treatments have been found effective. Similar results have been obtained by other workers and the use of oils for this purpose is said to be a long established practice of some farmers in India.

Village Level Impact of Machine Threshing of Sorghum

In contrast to the highly productive irrigated regions, diffusion of threshers in the SAT of India has not been widespread, demand being limited by such factors as revenue uncertainty, low wages, and the scarcity of double cropping opportunities. ICRISAT Village Level Studies (Binswanger and Jodha, 1978) supplied a valuable data base for evaluation of the impact of machine threshing of sorghum in a typical Indian SAT village - Kanzara, which is in the Akola district of Maharashtra State.

The first thresher was introduced into the village in 1976 and by 1980 there were four units, two inside and two outside the village. The threshing technology rapidly diffused throughout the village and mechanical threshing has almost entirely displaced traditional methods. Economic superiority may stem from reduced per unit cost of converting harvested produce into threshed grain, decreased threshing losses, and cleaner grain with lower percentage of brokens. A full report on this study is available (Walker and Kshirsagar, 1981). The general results from the study strongly suggest that the introduction and widespread diffusion of machine threshing in the village did not significantly reduce costs, increase cropping intensity, or displace labour. The results from one village cannot be expected to apply to all of SAT India, however, they do provide a reference point for analysis of the likely consequences of machine threshing in other socio-economic and agro-climatic settings.

Other Economic Studies

A project has just started at ICRISAT on investigating marketing of groundnuts. It is intended to describe marketing channels in India and worldwide, to assess relative preferences for quality attributes as expressed in market price in India, and to assess relative world markets for confectionary versus high oil varieties.

The Problem of Aflatoxin Contamination of Groundnuts

Aflatoxin contamination is a serious problem for the groundnut industry in the SAT and as such is given high priority in the ICRISAT program. Aflatoxins are toxic and carcinogenic substances produced when certain strains of the fungus Aspergillus flavus grow on groundnuts or other suitable substrates. Several factors are known to predispose groundnut pods to invasion by A flavus and other soil fungi. Insects can damage shells and seeds during crop growth, field drying and storage, termite attack being particularly important. Such damage can lead to invasion of seeds by A flavus. Mechanical damage to pods by cultivations or by processing machinery can have similar effects. Pod-rotting fungi, which damage, but do not always destroy pods, may facilitate invasion of seeds by the fungus. Delayed harvesting, and slow and irregular field drying, can also result in seed invasion by A flavus and other fungi commonly present in a quiescent state in shells of 'healthy' pods. Drought stress, particularly during late stages of pod development, can also lead to increased invasion of pods by A flavus. Seeds in storage may be accidentally wetted by rain water, by rising ground water, or by moisture resulting from insect infestation. Such wetting can result in rapid invasion of the groundnuts by A flavus and other mould fungi with consequent aflatoxin contamination.

From an understanding of the factors predisposing groundnuts to invasion by A flavus and aflatoxin contamination it was possible to formulate crop handling and storage methods which could prevent or at least greatly reduce the risk of conatamination occurring. These methods have been applied with considerable success in countries with developed agriculture but have not been widely adopted by the small scale farmers of the SAT.

As ICRISAT is concerned with the problem at the farmers' level, and as cultural control measures have not been adopted or have not proved successful, the research strategy followed has been that of utilisation of genetic resistance with a view to developing cultivars with pods or seeds which the toxigenic A flavus cannot invade, or , if invaded, do not support production of aflatoxins. As ICRISAT houses the world collection of groundnut (Arachis hypogaea L) germplasm, and also has an expanding collection of wild Arachis species, there is ample material available for screening. In this paper only those aspects of the research which have relevance to post harvest problems will be covered.

Dry Seed Resistance to Invasion by A flavus

It is well known that the testa of an undamaged, mature groundnut seed protects the cotyledons and embryo from invasion by seed surface contaminating fungi when the seeds are wetted or absorb moisture (Carter, 1970). Mixon and Rogers (1973) reported that seed of the two breeding lines, PI 337394 F and PI 337409, had marked 'dry seed' resistance to invasion and colonisation by A flavus when subjected to an innoculation test. The test is carried out on undamaged, mature seeds that have been dried and stored for at least one month. Water is added to a sample of approximately 20g of seed to raise their moisture contents to 20-25%. The seeds are surface sterilised by soaking in a 0.1% aqueous solution of mercuric chloride, rinsed in sterile water, surface innoculated with 1 ml of conidial suspension of A flavus, and then incubated at 25°C for 8 days. The percentages of seeds with sporulating colonies of A flavus are then recorded. Genotypes with up to 15% of seeds colonised are regarded as resistant, 16-30% as moderately resistant, 31-50% as susceptible, and over 50% as highly susceptible. Growth and sporulation of the fungus is normally sparse on resistant seeds but dense and profuse on susceptible ones (Mehan & McDonald, 1980).

Using this test, some 400 germplasm lines have been screened at ICRISAT for resistance of seeds to invasion and colonisation by toxigenic isolates of A flavus. Breeding lines reported resistant in the USA have also proved resistant in the ICRISAT tests and 5 new sources of resistance have been identified (Table 1), two of which are recognised cultivars (J II and Faizpur).

This 'dry seed' resistance could be of value when pods or seeds are accidentally wetted in storage. The resistance to invasion lies in the testa and any damage to this organ removes or greatly reduces it. This is unfortunate as several of the decortication methods used at the farm or village level in the SAT can cause extensive damage to seeds. The resistance may therefore be of greater value when the groundnuts are stored in shell.

Resistance in Groundnuts to Aflatoxin Production

Early research reported varietal differences in aflatoxin production (Kulkarni et al, 1967; Rao and Tulpule, 1967) when autoclaved seeds of different cultivars were colonised by toxigenic strains of A flavus. Although these claims were not confirmed by later research (Doupnik, 1969, Aujla et al, 1978), quantitative varietal differences were definitely indicated. The value of a genotype that would not support aflatoxin production in the event of seeds being colonised by a toxigenic strain of A flavus is obvious. Such seeds might develop high levels of free fatty acids but would not contain aflatoxins which in many markets could render the produce valueless. A modification of the test described above for screening genotypes for 'dry seed' resistance to A flavus invasion was used to screen genotypes for their ability to support aflatoxin production. Test seeds had their testas damaged by scratching them with a needle. The seeds were surface sterilised with mercuric chloride as already described, their moisture contents raised to 20% and they were then surface innoculated with a conidial suspension of a toxigenic strain of A flavus. The seeds were incubated at 25°C and samples removed after various lengths of time and tested for aflatoxin content by the method of Nabney and Nesbitt (1965). Table 2 gives Aflatoxin B_1 production figures for several genotypes including some with seed resistance to A flavus invasion. Unfortunately, there does not appear to be any correlation between resistance to seed invasion by A flavus and the ability of the seed of a genotype to support aflatoxin production. The genotypes FESR-11-P11-B2-B1, that showed the lowest level of aflatoxin in the test illustrated, had seed which were highly susceptible to invasion by A flavus. Figure 1, which is taken from another experiment, shows how the rate of aflatoxin accumulation is considerably slower in this genotype than in several others tested at the same time.

All genotypes tested to date, about 150 of them, have supported aflatoxin production to some degree. Screening will continue and in the meantime the plant breeders will be trying to combine factors for resistance of seeds to A flavus invasion and inability of seeds to support aflatoxin production. Genetic resistance of the desired type would lessen the risk of aflatoxin contamination and of mould damage in general. However, it would still be desirable to have good storage facilities with protection from wetting and prevention of insect infestations.

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Table 1. Genotypes resistant to seed colonization by toxigenic *A. flavus* at ICRISAT.

Genotype	Source	Percentages of seeds colonized by *A. flavus*	
		Rainyseasons	
		1980	1981
UF 71513[a]	USA	6.6	9.5
PI 337394 F[a]	Argentina	8.1	12.6
PI 337409[a]	Argentina	9.4	13.3
J 11[b]	India	12.0	12.5
Ah 7223	Nigeria	4.5	10.4
Var. 27	Australia	9.0	10.3
Faizpur	India	9.7	11.5
Manir 240-30		9.8	12.9
TMV 2[b]	India	36.7	36.2
OG 43-4-1[c]	India	91.2	93.2
S.E. ±		1.36	1.22
C.V. (%)		11.95	9.40

a. Lines reported resistant in USA
b. Commonly grown cultivar
c. Susceptible check

Table 2. Aflatoxin B_1 production in groundnut cultivars resistant and susceptible to seed invasion by toxigenic *A. flavus*

Cultivar	Reaction to seed invasion by *A. flavus*	Aflatoxin B_1 (ug/g seed)
PI 337394 F	Resistant	106.4
PI 337409	Resistant	95.5
J 11	Resistant	117.3
Ah 7223	Resistant	115.2
Nonir 240-30	Resistant	93.6
Var. 27	Resistant	90.3
Faizpur	Resistant	113.5
TMV 2	Susceptible	226.2
FESR-11-P11-02-B1	Highly susceptible	50.0
OG 43-4-1	Highly susceptible	76.3
C.D. (at 5%)		13.2
C.V. (%)		7.1

Fig. 1: Aflatoxin B_1 accumulation in inoculated seeds of 4 cultivars incubated at 25 ± 3°C.