On-farm monitoring and management of aflatoxin contamination in Australian peanuts

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Abstract

Aflatoxin contamination in peanuts is a major food safety issue world-wide and costs the Australian peanut industry (processors and growers) between $5-10M p.a. via analytical costs and associated sorting losses. This paper describes an aflatoxin monitoring and management strategy developed by researchers from the QDPI&F at Kingaroy to minimise pre-harvest aflatoxin contamination in rainfed peanuts grown over 11 peanut farms in the Burnett District of Queensland during the 2000-01season, which was rated as one of the most severe aflatoxin risk seasons. According to industry statistics, 60% of commercial loads tested positive for aflatoxin contamination while there was substantial reduction in aflatoxin from farms that adopted the aflatoxin minimisation program implemented by QDPI&F (only 22% of loads positive)

Media Summary

A novel aflatoxin risk monitoring and management strategy to minimise pre-harvest aflatoxin contamination in peanut has been developed by researchers at QDPI&F, Kingaroy.

Key words

Risk prediction model, Aflatoxin management.

Introduction

Aflatoxins are a group of toxins produced in peanut kernels by the fungi *Aspergillus flavus* and *A. parasiticus* under end-of season water deficits and associated elevated soil temperatures. Because of its carcinogenic properties aflatoxin contamination in peanuts presents a major food safety issue throughout the world. The Australian processing sector (peanut butter, confectionary, snack foods) also expend large resources on testing and quality assurance programs to ensure aflatoxin levels in retail products are kept well below the maximum permissible level of 15 parts per billion (ppb). With payment penalties depending on severity of aflatoxin contamination, there is obvious concern among peanut growers on the future viability of growing the crop, especially under rainfed conditions where aflatoxin risk is highest.

It is well known that prolonged end-of-season drought with associated elevated soil temperatures predispose the crop to aflatoxin risk. In addition, poor management during harvest can also significantly increase aflatoxin risk in storage. GRDC-funded aflatoxin minimization projects implemented over the period from 1999 to 2003 resulted in the development of management practices to minimise aflatoxin contamination (NagewaraRao Rachaputi *et al* 2000). Although management practices are reasonably straight forward, their utility is very dependent on effective monitoring of aflatoxin risk during the pod-filling phase. These projects also resulted in development of a simulation model for predicting on-farm aflatoxin risk using in-season climate data and soil temperatures. The modelling approach allowed an integrated understanding of environmental factors for the prediction of aflatoxin risk on a daily time step, and thus the assessment of aflatoxin risk on a site-by-site basis. This paper describes the aflatoxin monitoring and management program developed by QDPI&F to minimise on-farm aflatoxin contamination and its impact on dry land peanuts grown in the Burnett district of Queensland during 2001-02, which was rated as a very high aflatoxin incidence year.

Methods

Sites

During the 2001-02 season the DPI&F aflatoxin monitoring and management system was implemented on 11 peanut farms in the north and south Burnett district of south-east Queensland (Fig.1). For each site information on crop and soil data (planting and harvest date, variety, soil water holding properties and daily mean soil temperature in pod zone) and daily climate data (air temperatures, radiation and rainfall) was collected and used as input into the APSIM peanut aflatoxin model.

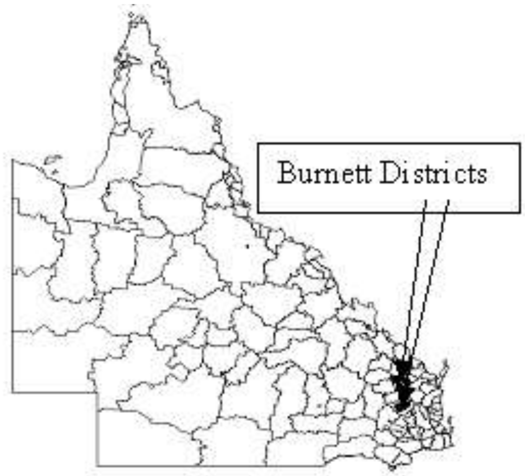

Fig 1. Dry land peanut growing regions of Queensland, Australia

Monitoring tools

On each farm, a rain gauge and an automatic temperature logger with air and soil temperature probes were installed in the crop early in the season. The soil temperature probe was placed at a depth of 5-7 cm in the pod zone directly under the peanut row. Data from the loggers were downloaded at weekly intervals during the season. Daily rainfall data were recorded by farmers and supplied to the QDPI&F staff for use in the model. Crop maturity was monitored (based on blackening of inner shell wall) at weekly intervals from 100 days after sowing until final harvest from a 500 g sample of pods collected from plants randomly selected in the field. At final harvest, a sample of about 5 kg of pods was collected from each site, oven dried down to <10% pod moisture at 60^{o}C and stored until aflatoxin analysis was conducted using immuno-affinity column assay.

Aflatoxin Risk Prediction model

The aflatoxin module was developed as a part of the APSIM peanut model (Robertson *et al* 2002) to compute an “aflatoxin risk index” (ARI) which indicates the severity of aflatoxin risk at a given site. A series of glasshouse and growth chamber experiments were conducted to understand the effect of soil water and temperature on aflatoxin production in detached peanut pods. The relationships developed from these experiments were used in the APSIM peanut model to simulate an ARI in response to the combined effects of soil water stress and soil temperature in a daily time step starting from the start of pod filling phase (Wright *et al.* 2003)

The ARI approach provided an assessment of the in-season aflatoxin risk, which was used by peanut growers as a tool for making harvesting time decisions to minimize aflatoxin contamination. The output from the model was converted into a one-page brochure consisting of graphical outputs of seasonal changes in soil water, soil temperature and predicted ARI.

Results

During 2001-02, the rainfed peanut crops in the Burnett region of Queensland were exposed to severe aflatoxin risk due to widespread end-of season droughts and elevated soil temperatures throughout the Burnett District of Queens land (see Fig 2).

However, predicted aflatoxin risk varied from 0 to >80% across the 11 monitored farms depending on the distribution of rainfall and soil temperatures (Fig 3). Results from the 2001-02 season, as well as previous years, showed that the model was reasonably accurate in predicting the aflatoxin risk (R^2 = 0.78), although it could not predict the actual levels of aflatoxin (Fig 3).

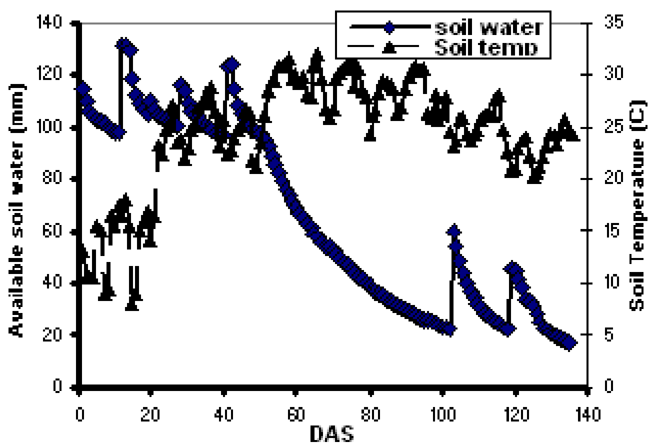

Fig 2. Seasonal changes in available soil water and soil temperatures in Kumbia region in South Burnett during 2001-02 season.

Factors such as sampling and soil heterogeneity in the farm can significantly influence the aflatoxin concentration (NageswaraRao Rachaputi *et al* 2000). The results also showed that measured aflatoxin levels from two farms (square symbols in Fig 3) were not in agreement with the general relationship. Further analysis of pods from these two sites showed that there was a severe incidence of *Etiella* (a pod borer) during the end of the season, which resulted in severe post-harvest aflatoxin contamination. These observations highlighted the inability of the model to account for aflatoxin risk associated with other factors (e.g. soil insects.).

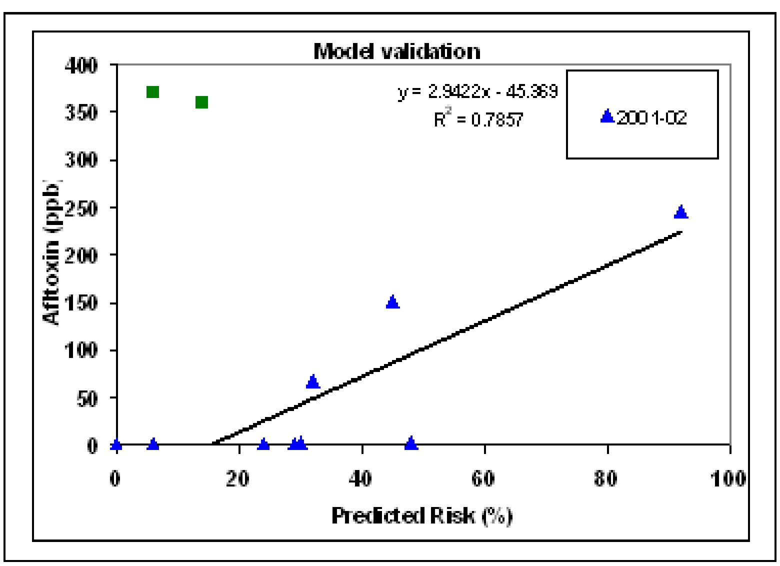

Fig 3. Relationship between predicted aflatoxin risk and observed aflatoxin levels in peanut kernels harvested from farms monitored during the 2001-02 season. (The two square symbols are from farms where there was a high *Etiella* incidence at harvest).

Intake records from the Peanut Company of Australia (PCA) showed that during the 2001-02 season > 60% of loads delivered to the shelling plant from dryland areas tested positive for aflatoxin, suggesting there was good agreement with predicted risk.

The one-page brochure containing graphical outputs of soil water, soil temperatures and predicted aflatoxin risk was communicated to the model farm growers at weekly intervals and assisted growers to assess the aflatoxin risk on their farms and hence make critical decisions on the timing of harvest (NageswaraRao Rachaputi *et al* 2000).

The impact of the project on minimizing on-farm aflatoxin contamination was assessed by comparing the aflatoxin levels in loads delivered to PCA from the monitored and unmonitored farms (Table 1).

Table.1 Industry statistics on aflatoxin segregations at intake for varieties 'Streeton' and 'Conder' grown on monitored and unmonitored peanut farms in the Burnett district during the 2001-02 season.

	Streeton		**Conder**	
Aflatoxin segregation at intake	% of loads from unmonitored farms (2919 tons)	% of loads from monitored farms (90 tons)	% of loads from unmonitored farms (1387 tons)	% of loads from monitored farms (147 tons)
Seg 1 (<8ppb)	35.3	58.4	46.3	69.8
Seg 2 (8-80 ppb)	34.6	41.6	30.6	6.6
Seg 3 (>0-400 ppb)	20.2	nil	13.6	23.6
Seg 4 (>400 ppb)	9.9	nil	9.4	nil

The results show that peanuts delivered from the farms which implemented the monitoring program of recommended aflatoxin minimisation technologies, had up to 24% higher number of Seg 1 loads (aflatoxin content <8ppb), compared to the unmonitored farms. More importantly, there were no Seg 3 or 4 loads (with aflatoxin >80 ppb) from model farms growing the variety 'Streeton', and no Seg 4 (aflatoxin content >400ppb) loads from the variety 'Conder'. The propensity of Conder to suffer growth cracks under drought stress may have contributed to the higher aflatoxin contamination in this variety.

Conclusion

These results demonstrated that pre-harvest aflatoxin contamination can be minimised by timely monitoring of aflatoxin risk parameters and implementing appropriate aflatoxin management practices such as timely harvest. Development of a user-friendly web-based decision support tool is underway to assist dryland peanut growers in making critical decisions about the implementation of on-farm aflatoxin minimization practices (see http://www.apsim.info/apsim/afloman/).

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