

Management Practices to Reduce Aflatoxin Contamination in Peanut

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ABSTRACT

The Australian Peanut Industry currently faces a serious challenge to rainfed production of peanut, with aflatoxin contamination becoming a major constraint for profitability. Under a GRDC-funded project, a series of field experiments have been conducted to investigate effects of two management practices, i.e. time of cutting and skip-row planting, on yield and aflatoxin contamination under a wide range of environments. It was apparent that any delay in harvesting the crop under end-of season droughts can severely reduce yields and increase aflatoxin contamination. Skip row planting (i.e. missing one row in every 3 rows) resulted up to 20% yield advantage and lower aflatoxin under severe end-of season drought conditions. However, in higher rainfall environments, skip rows resulted in up to 40% yield reductions compared to normal planting, suggesting that this practice should only be implemented in environments with high probability of end-of season droughts.

KEY WORDS

Peanut, end-of season drought, aflatoxin, management practices, gross returns.

INTRODUCTION

Peanut (*Arachis hypogaea* L.) is an important commercial crop grown across 40,000 ha in Queensland, with a large proportion of the production occurring under rainfed regions in the Burnett region. Yields of rainfed peanut crops are often low (<1.0 t/ha) and erratic (ranging from 0.4 t to >3 t/ha) due to unpredictable droughts during the growing season. Aflatoxin is a human carcinogen that contaminates peanuts, particularly under end-of season drought and makes them unsafe for human consumption. In Australia, although aflatoxin has been a problem for the peanut industry for nearly 20 years, shellers have recently imposed penalty payments of between \$150 and \$450 per tonne on loads contaminated with aflatoxin levels over 15ppb. High probability of end-of season droughts, with associated aflatoxin incidence, clearly threatens the viability of rainfed peanut in the Burnett region of Queensland (Wright and Hansen 1997). There is therefore an urgent need to find solutions to the aflatoxin problem via the implementation of crop management and/or genetic strategies. These strategies however depend on a thorough understanding of the conditions leading to high aflatoxin incidence. Aflatoxin production occurs in peanut kernels when the *Aspergillus flavus/parasiticus* fungus is present under conditions of lowered water activity (in the range of 0.8 to 0.95) and favourable temperatures (25 to 32°C) (Dorner *et al.*, 1989). Such conditions can occur at both pre- and post-harvest stages of the crop, depending on the duration of end-of season drought and soil temperatures.

A recent GRDC-funded project investigated a number of management practices aimed at minimising the aflatoxin contamination in peanuts. This paper describes two such practices that can improve yield and reduce pre-harvest aflatoxin contamination and hence contribute to the sustainability of rainfed peanut production in Queensland.

MATERIAL AND METHODS

All experiments were conducted on farmers fields in the Burnett region of South Queensland during the 1998-2000 growing seasons (Oct - May), under rainfed conditions, using the variety Streeton for the "cutting time" experiments, and NC7 and Streeton for the "skip-row planting" trials. Crops were planted in 90cm rows with a 15-cm intra-plant spacing and protected from pests and diseases throughout the season.

Effect of time of cutting

The effect of cutting time on yield and aflatoxin contamination was examined at two locations during the 1997-98 and 1998-99 seasons, and at five locations in 1999-00 season. There were three cutting time treatments during 1997-98 and 98-99 (Cut 1, Cut 2 and Cut 3) and two treatments (Cut 1 and Cut 2) during 1999-00, where Cut 1 = 2 weeks earlier than the farmers practice; Cut 2 = the farmers practice and Cut 3 = 2 weeks later than the farmers practice.

The plot size of cutting treatments varied (e.g. from 6m x 4 rows to 50m x 4 rows) with four replications. At each cutting time, the plot area was measured and crop harvested using a mechanical digger. Plants were allowed to dry in windrows for up to 4 days, before thrashing, using a small plot thrasher. The pods were collected in bags and dried in a bed drier for 4 days before pre-cleaning and weighing for pod yield. Aflatoxin analysis (described below) was conducted on a 1kg pod sample drawn from the yield sample.

Skip row planting

Skip row planting arrangement involved leaving every third row unplanted allowing plant roots to access stored soil water in the vacant row and hence perform better than plants under normal row spacing. There were two treatments, skip row and normal planting arrangement, with plot size varying from 25m to 50m length x 6 rows. The skip row experiment was conducted at five locations during the 1998-99 and 1999-00 seasons, using Streeton and NC7 varieties. Harvesting and yield recording was performed as described in the "time of cutting" experiment.

Aflatoxin analysis

Aflatoxin was determined using the mini-column method (Horowitz, 1970) for the 1997-98 and 1998-99 seasons, and the immuno-affinity column method (Truckess et al. 1991) for the 1999-00 season.

RESULTS AND DISCUSSION

Weather

During the 1997-98 season the crop suffered severe drought conditions with warm ambient temperatures (~30°C mean) experienced during the pod filling period. During the 1998-99 and 99-00 seasons, crops again suffered end-of season droughts, however ambient temperatures were considerably lower (~25°C mean) than 97-98 season. There were however substantial temperature variations experienced among sites during latter two seasons with soil temperatures recorded at Kumbia and Wooroolin sites being considerably cooler (<25°C mean) than the Coalston Lake sites (>27°C). These temperature differences had significant effects on aflatoxin contamination.

Effect of cutting time on yield and aflatoxin contamination

Delaying harvest had significant effects on pod yields, with yield losses in cut 2 and 3 being highly significant during the 1997-98 season (Table 1). The pod yield response to Cut 1 across locations and seasons ranged from negative (e.g. at the DLT site in 99-00) to highly positive (e.g at the RCK site in 97-98). The yield reductions recorded in Cut 2 and 3 were often associated with detachment of over-mature pods resulting in substantial harvest losses under severe drought conditions.

Detached and over-mature pods are also highly vulnerable to invasion by soil insects, *Aspergillus* fungi and consequently aflatoxin contamination (Cole *et al* 1989). Substantial aflatoxin contamination was present during the 1997-98 with significant reductions in aflatoxin recorded in Cut 1 treatment. During the 98-99 and 99-00 seasons, aflatoxin contamination was considerably lower compared to the 1997-98 season. A number of sites (NTH in 98-99 season, RCK and SBK in 99-00 season) however showed high levels of aflatoxin at Cut 2. This variation in aflatoxin across locations during the 98-99 and 99-00 seasons was associated with significant differences in soil temperature during last 30-40 days before

harvest (see Weather section). These results clearly showed that aflatoxin contamination was significantly reduced by cutting the crop early in sites where soil water deficits and soil temperatures were conducive to aflatoxin production.

Gross returns are based not only on yield but also on seed grades and levels of aflatoxin contamination. Although the yield difference between Cut 1 and Cut 2 was small in some situations (eg. RCK, SBK in 1999-00), gross returns were significantly higher at Cut 1 compared to Cut 2 (Table 1). These results suggested that in years of high aflatoxin risk, gross returns could be maximised by harvesting the crop earlier than the currently used practice. In low aflatoxin risk years/sites however, it is important that the crops are left until optimum maturity, in order to maximise yield, seed grades and gross returns (e.g DLT site 1999-00). The results from the current study also suggest that there is a need to review the definition of optimum harvest time depending on aflatoxin risk.

Table 1. Effect of time of cutting on yields, aflatoxin contamination and gross returns (variety Streeton), grown in a range of environments in the Burnett region during 1997-98, 98-99 and 99-00 seasons.

Year	Locat-ion ID#	Pod yield (kg.ha)				Aflatoxin (ppb)				Gross Returns (\$/ha)			
		Cut1	Cut2	Cut 3	Sig ##	Cut1	Cut2	Cut 3	Sig ##	Cut 1	Cut 2	Cut 3	Sig ##
97- 98	RCK	2314	1440	1528	**	132	1002	867	*	2812	1261	1199	**
	JHN	2891	2084	1351	**	142	536	240	*	2913	1778	1375	**
98- 99	WEL	3351	3026	2598	**	1	2	10	Ns	2514	2369	2094	ns
	NTH	2688	2303	2125	*	5	680	2	*	2027	985	1714	*
99- 00	RCK	1859	1887		ns	10	64		*	938	831		*
	SBK	1601	1547		ns	0	226		*	835	655		**
	DLT	3577	4246		ns	1	3		Ns	2158	2500		*
	MKL	1709	1519		*	0	0		Ns	871	790		ns
	UNV	2460	2427		ns	1	1		Ns	1542	1570		ns

DLT = Darlingtons (Binjour), JHN = Johnstons (Kumbia), MKL = Markwells (Binjour), NTH = Northcotts (Kumbia), RCK = Rackemanns (Coalston lakes), SBK = Seabrooks (Coalston lakes), UNV = Unverzaghts (Kumbia), WEL = Wellers (Wooroolin).

Statistical significance with * = $P > 0.05$; ** $P > 0.01$ and ns = not significant

In particular, our results suggest that three major factors need to be considered in making the correct harvest decision. These are (1) optimal maturity in the absence soil water deficit and high temperatures, possibly based on a thermal time model, (2) extractable water in the soil during the pod filling period, and (3) soil temperatures during the pod filling period. Using these parameters, an aflatoxin prediction model is currently being developed as a module in the APSIM peanut model to indicate aflatoxin risk in a given growing season. On-farm trials are also underway to validate the model's ability to predict aflatoxin risk and optimum cutting time for a number of peanut growing environments in South Queensland.

Skip row planting

Results from the skip row experiments showed that in most of the locations there was a yield loss (up to 1500kg/ha) in skip rows compared to normal planting. Interestingly, at some locations (eg. JHN and RCK in 98-99 and RCK in 99-00), there were yield benefits and improved gross returns of up to 400 \$/ha in skip rows. (Table 2). Although the effect of skip row on aflatoxin contamination was not consistent across sites, there was a trend for reduced aflatoxin incidence under skip row plant treatment .

Further analysis of the data indicated that yield benefits due to skip rows were closely associated with the rainfall distribution, particularly during the pod filling period. In environments where the cumulative rain fall during the pod filling period was less than 100mm, skip row planting resulted in yield benefits and improved gross returns (Figs.1a and b). Under severe drought environments (e.g. RCK), crops under skip row arrangements also had superior seed grades which contributed to increase in gross returns, compared to the normal planting.

CONCLUSIONS

Research has shown that in years of high aflatoxin risk, aflatoxin contamination could be minimised and gross returns maximised by harvesting the crop earlier than the currently used practice. There is a need to develop decision support tools to assist in assessment of aflatoxin risk and the associated harvesting time decision.

Pod yield benefits from skip row planting were only apparent under severe end-season drought suggesting that this practice should only be implemented in environments with a high probability of late season drought.

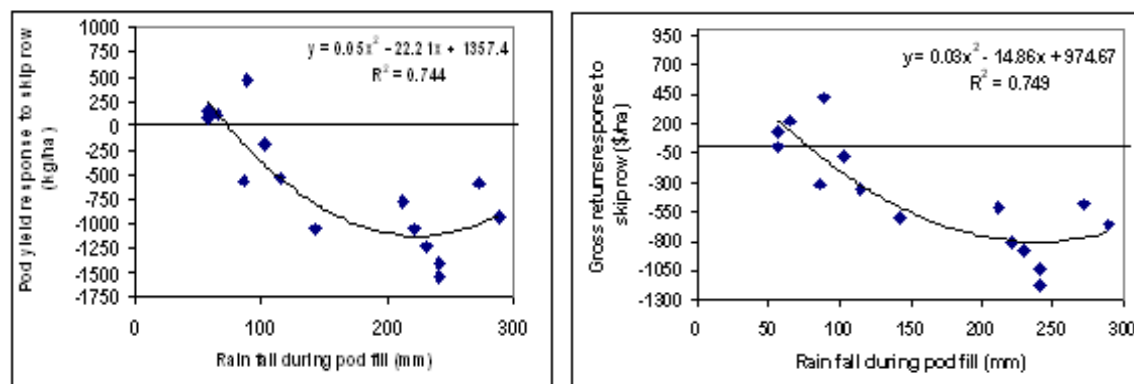
Table 2. Effect of skip row planting on pod yield, aflatoxin contamination and gross returns for Streeton and NC 7 grown in a range of environments in the Burnett during 1998-99 and 99-00.

Year	Locatio-n ID#	Var	Pod yield (Kg/ha)			Aflatoxin ppb			\$ Gross returns/ha		
			Normal	Skip row	Sig ##	Normal	Skip row	Sig ##	Normal	Skip row	Sig ##
98- 99	WEL	NC7	3313	2267	*	7	10	ns	2556	1759	*
	WEL	STR	3351	1948	*	1	0	ns	2514	1477	*
	JHN	NC7	2820	3288	**	7	17	ns	2203	2621	**

	NTH	NC7	2565	1636	*	2	1	ns	2090	1433	*
	NTH	STR	2688	2106	ns	5	5	ns	2027	1539	ns
	RCK	NC7	558	641	ns	816	220	*	260	386	ns
	RCK	STR	876	1031	ns	6	23	ns	637	643	ns
	HNS	STR	3920	2688	*	1	1	ns	2986	2101	*
99-00	RCK	STR	1859	1972	ns	10	3	ns	938	1160	ns
	DLT	STR	3577	2529	**	1	0	ns	2158	1563	*
	MKL	STR	1710	1520	ns	0	0	ns	870	790	ns
	JHN	NC7	3257	2727	*	0	1	ns	2177	1820	ns
	UNV	STR	2460	1690	**	0	0	ns	1542	1037	**

and ## Legend details given in Table 1

Figure 1. Effect of skip row planting on yield (a) and gross returns (b) in on-farm trials conducted across the Burnett region during the 1998-99 and 1999-2000 years



ACKNOWLEDGMENTS

Funding support for this work from GRDC and the Peanut Company of Australia is gratefully acknowledged. We also acknowledge the support and collaboration from a number of peanut growers in Wooroolin, Kumbia, Binjour and Coalston Lakes of South Queensland where these on-farm trials were conducted.

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