Achieving the Genetic Potential of Peanuts in Irrigated Production Systems

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ABSTRACT

The peanut industry has recently expanded production into irrigated production systems throughout Queensland. Commercial pod yields achieved on farmers fields have been low, and are often 3 to 4 t/ha below that of the varietal potential of 7 to 8 t/ha. A new GRDC funded project on 'Achieving genetic potential of existing peanut varieties in high input irrigated production systems throughout Queensland' has developed a network of focus groups to conduct 'on-farm' trials investigating agronomic constraints to the achievement of the varietal potential of peanuts. Initial trials in this project have investigated the value of late nitrogen fertiliser application in improving peanut yield and grades, as well as studies aimed at benchmarking crop performance in farmers' fields. Three on-farm nitrogen trials conducted in south and central Queensland have shown there is little yield and quality response to late nitrogen application, and that the economics of this widely used practice is of limited value. Benchmarking studies using a crop modelling approach have provided a useful framework to analyse harvested pod yield performance relative to the attainable and genetic yield potential.

KEY WORDS

Peanuts, nitrogen, modelling, variety, yield potential, participatory.

Introduction

Current commercial peanut yields under high input irrigated systems in north (NQ), central (CQ) and south (SQ) Queensland are between a third and a half of the yield potential achieved in experimental and breeding plots. For example, intake figures from the Peanut Company of Australia (PCA) show that commercial yields of between 2 to 4 t/ha are common for current commercial varieties (e.g. Streeton, NC-7, Florunner), while experimental yields and leading grower yields often reach 7 – 8 t/ha. A number of factors have been associated with this yield 'gap', including inadequate or uneven plant populations, poor irrigation management, inadequate disease control, poor rotations (e.g. continuous peanuts), nutrient imbalances and harvest losses associated with over/under-maturity and/or machinery inefficiencies. The irrigated production areas of NQ, CQ and SQ currently amount to around 13,000 ha, with recent rapid expansion particularly in CQ (Emerald and Mackenzie Valley) and SQ (Inglewood, Texas, Chinchilla, St George). PCA, in consultation with industry experts, estimate that by realising the genetic potential of existing varieties (i.e. raising pod yield from 2.6 to 7 t/ha over this 13,000 ha), the benefit to growers and industry would be in the order of $38M. These calculations are based on the assumption that surplus product would have to be sold on the world market at world parity prices (*ca*. $350USD) (R.B. Hansen, pers. comm.).

In response to industry and grower requests to address the known yield 'gap', the Queensland Department of Primary Industries (QDPI) has initiated a new GRDC funded project entitled 'Achieving genetic potential of existing peanut varieties in high input irrigated production systems throughout Queensland'. This project aims to (i) identify the major agronomic/management factors limiting the achievement of genetic yield potential in irrigated systems (ii) establish participative on-farm research, development and extension teams in each region to research and extend relevant issues, and (iii) develop and use of the APSIM peanut crop model to assist in monitoring, benchmarking and decision support.

A major activity of this project will be to enhance and expand ‘on-farm’ research experiments/demonstrations currently conducted by growers and private consultants.

This paper reports two on-farm research studies conducted during 1999-2000 within the framework of the participatory research model, including: i) the effect of late season N application on peanut yield and quality. Late N application is currently being practiced by many growers, however there is considerable controversy regarding the benefits of this practice, and ii) the use of a computer simulation approach to define pod yield potential under prevailing environmental conditions. Both studies provided good opportunities to evaluate the ability of the participatory on-farm research approach to mediate grower adoption of new peanut management practices.

Materials and Methods

Nitrogen application experiments were undertaken in the field at three locations during the 1999/00 season. All experiments were conducted on light textured soils of alluvial origin and neutral to slightly acid pH. The experiments were established on farmers fields near Coominya (SQ), Texas (SQ) and Gogango (CQ) and were fully irrigated, with pests and diseases controlled using appropriate chemicals. Soil nitrate levels at each site were low (< 20 mg/kg in the surface 10cm of soil). There were three N treatments in a randomised complete block design, with four replicates, which included a zero control (no N), and two levels of fertiliser N (as urea) applied in the last 6 weeks. Details of these treatments and other relevant information are included in Table 1.

Table 1. Details of nitrogen experimental locations, variety and treatments.

Trial Location	Variety	N Rates (kg N/ha)	Timing of Application (DAP)
Coominya (SQ)	Streeton	0	
		80	103
		80 (4 * 20)	77, 91, 103, 119
Texas (SQ)	Florunner	0	
		30	171
		100	171
Gogango (CQ)	Conder	0	
		60	47

	60 (3 * 20)	47,60, 73

All N treatments were broadcast on the soil surface and were immediately followed by irrigation. Pod yield and grades (kernel size distributions) were measured at maturity, and crop value per tonne was calculated using pricing information from PCA. Final crop value ($/ha) was calculated as kernel yield (kg/ha) multiplied by crop value per tonne ($/t).

Benchmarking of crop pod yield performance was carried out using the QNUT peanut model (1), which has recently been adapted into the APSIM framework (Robertson et al, pers. comm.). Potential pod growth and final yield (Y_{pot}) of the variety Florunner, which was grown at two locations in SQ (Inglewood and Coominya), was predicted using APSIM peanut. Soil and climate inputs collected at each site, including available soil water content, irrigation and rainfall inputs, maximum and minimum ambient temperatures and total solar radiation, were used. Attainable pod yield (Y_{att}) was monitored at intervals during the podfilling period, by taking a $2m^2$ quadrat in each of four replicate blocks of the farmers' commercial crop. Final Y_{att} was measured at maturity by taking a larger quadrat area (up to $20m^2$). The actual pod yield harvested and delivered to PCA (Y_{act}) was recorded for each farmer. At the Coominya site, a severe weed infestation of mainly Star Burr (*Acanthospermum hispidum*) was present in the field. Samples for Y_{att} were therefore sampled in a weed-free region of the field adjacent to a QDPI peanut variety trial. The final pod yield harvested for the Florunner plots from this trial site were also recorded (Cruickshank et al, pers. comm.).

RESULTS and DISCUSSION

Nitrogen experiments

Many irrigated peanut growers in Queensland apply fertiliser N throughout the podfilling period to supposedly boost yield and grades. This practice seems widespread despite a wealth of published literature indicating that there is little or no response in peanut to late-season N fertiliser application (2). The results of the current experiments also demonstrate there were no significant late N treatment effects on pod yield, grade out or crop value at the Coominya and Gogango sites (Table 2). At the Texas site, there were some effects of late-season N on pod yield, kernel grades and crop value (Table 2). At this site there was a trend for pod yield and grades to be marginally higher (i.e. a higher percentage of jumbos and VK1's). This resulted in an increase in crop value of the order of $350/ha (zero vs 100 kg N/ha treatments), which represented only a modest increase (6.2%) above the zero N control. There were substantial differences in pod yield between the experimental sites, with the average yield being 4311, 6973 and 7400 kg/ha for Coominya, Texas and Gogango sites, respectively. The lower pod yields at the Coominya site were caused by a severe late season rust infection, which was unable to be controlled with fungicides. It was thus apparent that the late N application had no effect on increasing yield and grades where other yield constraints (i.e. disease) were operating, in agreement with the conclusions of Cox (3). They suggest that where yield responses to applied N have been observed, there have been problems with the crop N fixation system.

Table 2. Effect of late season fertiliser N application on peanut pod yield, grades, grade value and total crop value.

Location/ Treatment	Pod Yield (kg/ha)	Jumbo (%)	VK 1 (%)	Grade Value ($/t)	Crop Value ($/ha)
Coominya, SQ					
0 N	4421	7	8	824	2627

4 * 20 N	4245	10	11	846	2679
80 N	4268	14	11	836	2519
Lsd (P<0.05)	n.s.	n.s.	n.s.	n.s.	n.s.
Texas, SQ					
0 N	6830	45	18	1072	5437
30 N	6931	49	19	1096	5724
100 N	7157	50	18	1095	5791
Lsd (P<0.05)	219.8	3.3	n.s.	14.4	261
Gogango, CQ					
0 N	7100	19	42	1100	7791
3 * 20 N	7400	18	40	1074	7895
60 N	7700	19	43	1085	8347
Lsd (P<0.05)	n.s.	n.s.	n.s.	n.s.	n.s.

The participatory approach used to conduct these on-farm experiments proved very successful, with farmers being involved in the design, conduct, analysis and interpretation of results. Small workshops were held prior to, during and at the end of the season to discuss plans and results. The general consensus among growers was that the N experiments across all regions clearly demonstrated there was little value in applying late N fertiliser. Even at the high yielding site (Texas) where a slight response was evident, growers agreed that it would be better to invest the approximately $100 spent on fertiliser N on management practices that could overcome more important yield constraints (e.g. extra fungicide sprays for foliar and soil borne disease control).

Benchmarking experiments

Two commercial peanut crops were monitored in the SQ region to compare pod yield in terms of three levels: actual (Y_{act}), attainable (Y_{att}) and potential (Y_{pot}), following the approach of Robertson (4). Y_{act} refers to pod yield that was delivered by the grower for payment to PCA. Y_{att} is the pod yield measured in quadrat samples before commercial harvest. The difference between Y_{act} and Y_{att} represents the impact of stand heterogeneity and pod harvest losses suffered during cutting and threshing operations. Y_{pot} was estimated using the APSIM peanut model and represents the pod yield determined by prevailing climatic conditions (not accounting for soil nutrients, weeds, pests and diseases). The difference between Yatt and Y_{pot} can hence be interpreted as the yield gap due to suboptimal management (e.g. poor plant stand, weeds, diseases). At the Inglewood site, Y_{act} was similar to Y_{att} suggesting the grower harvested yield was comparable with the maximum biological yield present in the field at harvest. However, the Y_{att} data shows the crop had begun to suffer some yield decline associated with over maturity leading up to the Y_{act} harvest. This suggests that harvesting earlier (presumably at optimum maturity) may have resulted in higher yields. The most important result from this Inglewood site was the extremely large discrepancy between Y_{pot} and Y_{act} (nearly 6 t/ha)(Figure 1). This apparent yield gap was associated with a number of management constraints, including inadequate plant stands, sub- optimal irrigation and some late season disease (white mould) infection.

At the Coominya site, there was close agreement between $Y_{pot\ and}$ Y_{att} indicating that the crop was growing near to the genetic potential for the Florunner variety (Figure 2). The final pod yield of approximately 8t/ha achieved in the QDPI variety trial was very close to that predicted by the APSIM peanut model. However, there was a large difference between Y_{att} and Y_{act} with the pod yield achieved by the grower (Y_{act}) being only half of the biological yield present in the field (Y_{att}). This 4t/ha yield ‘gap’ represents an enormous economic loss to the grower in the order of *cv*. $4000/ha. The major reason for this discrepancy was associated with a severe weed infestation in the commercial crop area under the pivot. The area where the yield samples for Y_{att} were taken was hand weeded, thus most of the yield gap we can attribute to weed competition. Although we do not have definitive data, it was also suspected that harvest losses were significant and may have contributed to the yield gap.

The benchmarking exercise using the concept of actual, attainable and potential pod yield has allowed an effective analysis of constraints operating in peanut growers’ fields in southern Queensland. It is of great interest that while the Coominya peanut field grew and yielded very close to the genetic potential, a simple management constraint (i.e. effective weed control) was largely responsible for causing a yield reduction of nearly 4 t/ha. This lost production was equivalent to a loss in gross earnings of approximately $200,000 over the 50 ha pivot, which could have been achieved by the use of a $750 herbicide application.

Figure 1. Potential, attainable and actual pod yield for a commercial peanut crop grown in the Inglewood, S. Qld region.

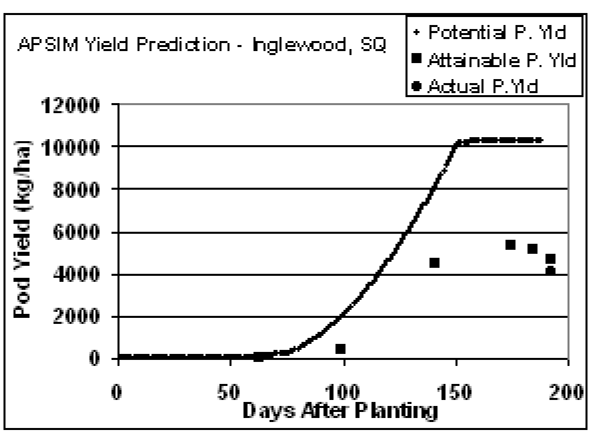
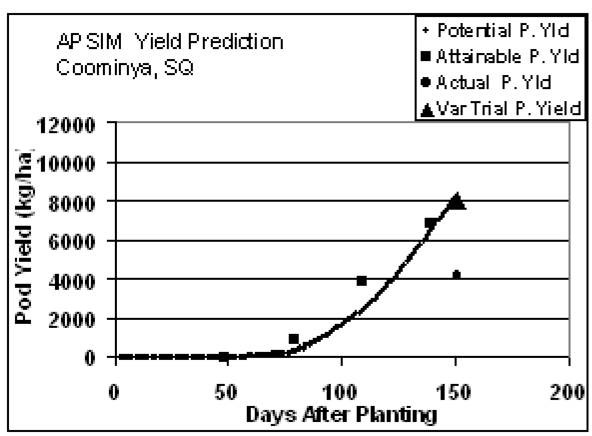


Figure 2. Potential, attainable and actual pod yield for a commercial peanut crop grown in the Coominya, S. Qld region.



CONCLUSIONS

A series of on-farm experiments investigated the use of late season application of nitrogen fertiliser to increase yield and quality of irrigated peanuts. In two of the three trials there was no yield or quality response to late N, while in the third experiment only minor benefits were recorded. It is recommended that there is little value in applying fertiliser N to peanut crops, and this practice represents an unnecessary expense for peanut growers. The benchmarking studies using a crop modelling approach can provide a useful framework to analyse actual pod yield performance relative to the attainable and genetic yield potential. Presentation of this type of data has been of great value in demonstrating to peanut growers that the difference between the theoretical and attainable yield can be quite small. The challenge for peanut growers is to refine a number of relatively simple agronomic management practices, such as even plant stands and weed management, to enable the achievement of these potential yields over large commercial areas. The participatory approach being used in this project has proven to be an effective method to conduct on-farm research, with substantial benefits for growers, consultants and researchers.

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