Broadleaf crops for diversification of dryland cropping in the northern wheat-belt of eastern Australia

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Abstract

The aim of this four-year study is to understand, and where possible overcome, constraints to the adoption of broadleaf crops in north-western NSW, with a focus on chickpea, faba bean and canola. A survey of 131 growers and advisers identified the major constraints to adoption of these crops as the risk of disease and concern about broadleaf weed management. A benchmarking study was also carried out in 2003 of growers in the study region already growing the 3 focus crops. It is anticipated that this data will be used to aid growers in decision making. For chickpea crops in 2003 the variables most associated with yield were plant available water (r^2=0.51); stubble cover (r^2=0.58) and nodulation (r^2=0.56). Frosts occurring late in the season were also particularly detrimental to some crops in the north-west region.

Media summary

Research in northern NSW, Australia is being carried out to understand the constraints to adoption of alternate crops to wheat, namely chickpea, faba bean and canola.

Key Words

Farming system, diversification, broadleaf, chickpea, yield, soil moisture

Introduction

Cropping soils in north-west NSW are characterized predominantly by self-mulching grey clays and black earths. It is a summer-dominant rainfall area with an average annual precipitation range of 500 to 670 mm, with 60% falling between October and March inclusive. Despite the summer dominant-rainfall winter cropping is predominant, particularly in the western boundaries of the region where rainfall is minimal. Current farming systems in north-west NSW are still largely reliant on cereal crops despite the potential for winter pulses such as chickpea and faba beans and oilseed crops such as canola to be included as valuable rotation crops.

Felton et al. (2001) found that wheat grown after chickpea can yield up to 0.9t/ha more than wheat grown after wheat. These results may be attributed to a number of processes including, in the case of legume crops, the potential nitrogen benefit provided to the subsequent cereal crop (Marcellos et al. 1998). The increase in cereal yield following a non-host broadleaf crop may also be attributed to the break in cereal diseases such as crown rot (*Fusarium pseudograminearum*) provided by non-host crops. For example, wheat planted after canola can potentially lead to a 0.5 to 1.0 t/ha yield increase when compared with wheat after wheat (Kirkegaard et al. in press). This benefit is of particular value in no-tillage environments where the potential of carry-over of cereal diseases borne on crop residues between successive crops is significantly increased (Burgess et al. 1993). The increasing availability of winter break crops such as chickpea, canola and faba bean provides the opportunity for wider adoption of no-tillage in the region.

The purpose of this 4 year study is to identify the constraints to the continued adoption of sustainable rotations in north-western NSW by analysis of paddock data, farmers' paddock records and farmers' responses to questionnaires. The project will produce simple diagnostic and analysis tools that farmers and advisers can use to monitor the performance of their crops and determine how they fit into the farming system. Appropriately packaged technical and financial information will also be produced.

Methods

Farmer questionnaire

During 2003, 131 farmers across the north-west of NSW were asked, considering their winter crop area, were they satisfied with the percent area of cereals to broadleaf crops namely chickpea, canola and faba bean. The proportion of these crops planted in 2003 as well as in normal years as a percentage of winter cereal, was recorded. Farmers were also asked if they planned to increase the area of broadleaf crops over the next 5 years and what they considered to be the main limits to expanding the area of chickpea, canola and faba bean.

Paddock benchmarking

Growers were located in a geographic region which spanned as far east as Delungra, north as North Star, west as Walgett and as far south as Mullaley. This is an area covering approximately 37 650 square kilometres. We collected data from 3 sampling points approximately 100 m apart in break-crop paddocks starting 50 m from the edge of the crop area. 3 sub-samples were taken from each sampling point and bulked. The following data was collected

- Plants/m^2, plant height (cm) and height of lowest pod (chickpea);
- Incidence of disease, weeds and insect damage;
- Nodulation score (ranked from 1-5 based on number of nodules) for chickpea and faba bean (Herridge pers comm)
- Stubble cover estimate using a photo standard technique (Molloy and Moran 1991).
- Immediately prior to crop harvest the paddock was revisited and at the same 3 sampling points the following data was collected
- Plants/m^2
- Grain yield
- Total dry matter (DM)

Plant available water (PAW) was estimated by taking 25% of fallow rainfall (November-April) and 100% of in-crop rainfall (May-October) as generated by SILO data drill (QNR&M 2003). Grain yield was determined from quadrat cuts as well as recording the overall paddock header yield. Estimated harvest losses were obtained by taking the difference between header and quadrat yield. Growers provided paddock management history. The paddock data was analysed initially using biplot analysis, which provides a graphic description of the relationship between variables measured during the benchmarking process. Linear regressions were then fitted for factors aligned positively or negatively with chickpea yield in the biplot analysis. Agricultural Production Systems Simulator (APSIM) was also used in order to identify the risk of receiving a frost of minus $1^{o}C$ or colder (at screen height) during late flowering/early-pod fill for various sowing dates at Walgett, Coonamble, Moree and Inverell.

Results

Farmer questionnaire

We surveyed 131 farmers and advisers in the Moree, Inverell, Narrabri and Gunnedah districts and found that the main limit to chickpeas and faba beans were the risk of disease, the cost and hassle of fungicides and concern over broadleaf weed management. A major limit to faba beans was the lack of a suitable variety and the price was considered too low and variable. The price of chickpeas was considered too variable. The main concern for canola was the lack of suitable harvest equipment followed by concern over broadleaf weed management. The respondents consistently gave a low ranking (i.e. not a limiting factor) to agronomic information and being convinced about the benefits of these alternative crops.

Benchmarking

Over the 38 broadleaf crops benchmarked in 2003, 22 were chickpea, 9 were canola and 7 faba bean. Due to the low number of canola and faba bean sampled, the following analysis will focus on chickpeas. It is anticipated that the data set for canola and faba beans will expand over the next 3 years of the project.

Factors affecting chickpea yield

Chickpea header yields averaged 1.3 t/ha in 2003. The first step in the analysis of on-farm paddock data was to do a biplot analysis to determine the level of alignment of variables with chickpea yield. Factors aligned positively with yield were estimated plant available water (PAW), stubble cover and nodulation score. Sowing date was negatively related to chickpea yield (late sowing reduced yield). Other measured variables were not found to have a significant correlation to chickpea yield.

The positive correlation between chickpea yield and estimated PAW in 2003 are shown in Figure 1a. It is interesting to note that amongst growers that had similar amounts of plant available water yield varied widely. It is likely that this variation may be largely due to the timing of rainfall events and farmer management practice.

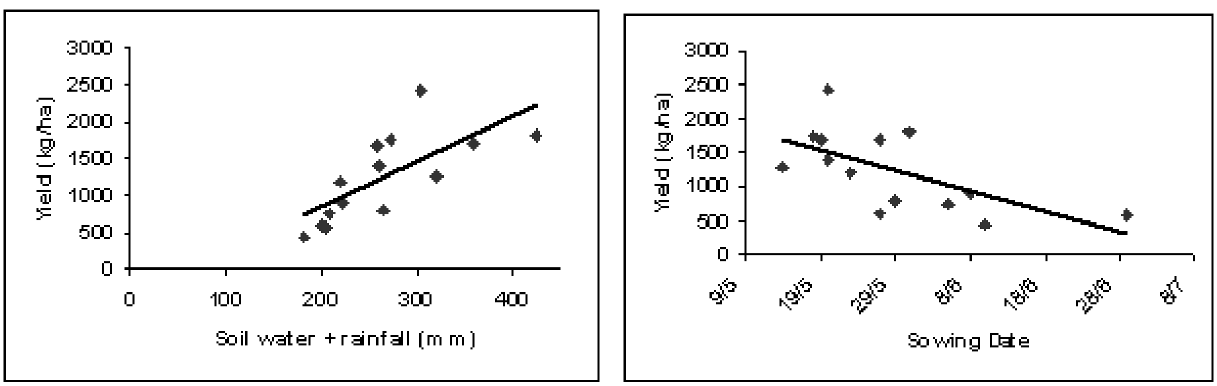

Figure 1. The relationship between (a) estimated plant available water and chickpea yield, y = 6.15x-390 (r^2=0.51) and (b) sowing date and chickpea yield, y=-30x+1686 (r^2=0.39).

Frost-risk is a major factor determining the sowing date for chickpea. The results of APSIM simulations showed that frost risk declines with later sowing dates and could be minimised to 10% or less by sowing: no earlier than early May in Coonamble; mid May in Walgett and Moree; and no earlier than early-June for Inverell (Table1.)

	Sowing Date						
	15-Apr	**1-May**	**15-May**	**1-Jun**	**15-Jun**	**1-Jul**	**15-Jul**
Coonamble	30	6	0	0	0	0	0
Walgett	34	15	2	0	0	0	0

Moree	57	21	2	0	0	0	0
Inverell	98	51	28	9	6	0	0

Table 1. Risk (%) of receiving a minus 1 ^{o}C frost or colder (at screen height) during late flowering / early-pod fill for various sowing dates at Walgett, Coonamble**, Moree and Inverell.**

However, growers with paddocks benchmarked in the Walgett and Coonamble areas tended to sow no earlier than early June. Although data from 2003 suggests there is not a strong linear relationship between yield and time of sowing it is statistically evident that sowing date has a significant impact on yield ($r>0.53$). This data suggests that with every day sowing is delayed after the 14 May there is a 30 kg/ha decline in grain yield (Figure 1b).

Stubble cover in 2003 was positively correlated with chickpea yield (Figure 2a). The highest ground cover was estimated at 55%, the lowest being no ground cover, with an average of 15%.Chickpea yield was also found to be positively aligned with nodulation score (Figure 2b).

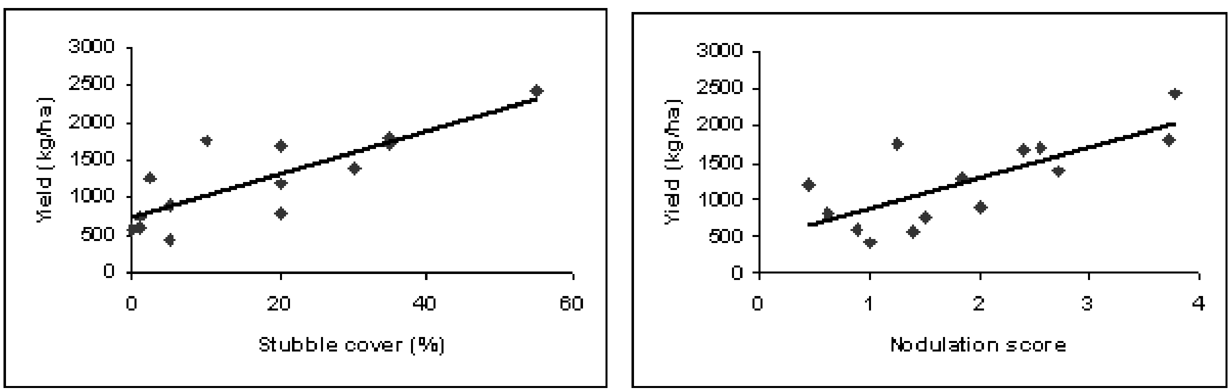

Figure 2. The relationship between (a) estimated stubble cover (%) and chickpea yield y=29x+744 (r^2=0.67) and (b) nodulation score and chickpea yield y=414x +463 (r^2=0.56).

Conclusion

The issues of disease and weed management in these broadleaf crops were identified by growers as constraints to production in this region. In terms of the scope of this project it is anticipated that by working to improve grower management some of these constraints may be alleviated.

The amount of water available to chickpea crops during its growing season and the associated yield varied across the study region. However, unless the distribution of rainfall events is taken into consideration, comparing the water use efficiency of one grower to another is not justified. For this reason setting a benchmark water use efficiency based solely on total amount of plant available water was not employed. It is anticipated that further analysis will enable the impact of farmer practice to be distinguished.

In identifying the factors which are imposing constraints on chickpea yield in the study region, one which may be recognized as being most readily managed by growers is time of sowing. The effects of sowing date, however, could be confounded with the effects of PAW as growers in drier areas have a tendency to sow later. Future sowing date experiments should make it possible to separate the effect that these two variables have on chickpea yield.

Although frost risk is a major constraint to early sowing of chickpeas, it is possible that growers in some regions may be placing too much emphasis on potential yield reduction caused by frosts. This is particularly evident in Walgett-Coonamble where it is common practice to sow in June with the intention of avoiding frost risk. There is a need for additional work to be done on the prospect of earlier sowing times in this region.

There could be a number of reasons for the low levels of nodulation in chickpea and further research is required. Possible causes of reduced nodulation could include high levels of NO_3 in the soil at sowing, which chickpeas are particularly sensitive to. We propose to investigate the survival of chickpea rhizobium strains in the soils of north-western NSW as well as genetic stability of introduced strains over time.

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