# NITROGEN FIXATION IN CHICKPEA AS AFFECTED BY PLANTING TIME AND TILLAGE PRACTICE

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*Summary.*Chickpea was grown as a cash grain legume crop using the management options of planting time and tillage practice to maximise $N_2$ fixation. Planting in autumn generally produced more fixed $N_2$ than planting in winter,although quantities fixed were low, ranging from 15 - 32 kg N/ha. This was due to high initial soil $NO_3$-N and lower than average rainfall which resulted in lower total chickpea biomass and subsequent lower $N_2$ fixation. Zero tillage enhanced grain N accumulation, but had no significant effect on $N_2$ fixation.

## INTRODUCTION

Continuous cultivation for cereal cropping in the major cereal growing areas of southern Queensland has led to depletion of soil organic C and N. This has resulted in decreased cereal crop yields and cereal grain protein concentrations in recent years, preventing farmers from obtaining ‘prime hard’ status (13% protein) for their wheat crop. Although chickpea (*Cicer arietinum L.) is* widely accepted in cereal rotations in the region, limited work has been conducted on management options to enhance its ability to fix atmospheric $N_2$. This study investigated time of planting and tillage practice as two management options. Three planting times within the autumn - winter period and two tillage practices, zero till (ZT) and conventional till (CT) were investigated for their effect on chickpea yield, N accumulation and $N_2$ fixation.

## METHODS

A field experiment was established following a twelve month fallow, in May 1992 using a randomised complete block design. The treatments in 1992 consisted of three sowing dates of chickpea, two crops (chickpea and wheat) and CT (3 cultivations with chisel plough and scarifier). ZT treatments were commenced after the harvest of chickpea and wheat crops in November 1992.

Desi type chickpea (cv. Barwon) was sown at 65 kg/ha on 1 May, 27 May, and 7 August 1992 and on 28 April, 8 June and 21 July 1993 in 22.5 x 6.5 m plots. Chickpea seed was inoculated with a rhizobium/peat mix at 250 g/50 kg seed and planted with 220 kg/ha of single superphosphate with Cu and Zn to supply 20 kg P, 2 kg Cu and 2 kg Zn/ha. A local weed, milk thistle (*Sonchus oleraceus L.)* was used as a reference plant for $^{15}$N natural abundance plant sampling. Soils were sampled for $NO_3$-N in April 1992 and 1993 and following the crop harvest in November in both years. Soil $NO_3$-N was extracted using 2N KCl and analysed on autoanalyser (1).

Chickpea dry matter samples were taken regularly from flowering to harvest to establish the time of maximum dry matter yield, and thus estimate the time of maximum $N_2$ fixation. Duplicate dry matter samples for $^{15}$N natural abundance were taken in each plot, using a chickpea plant and reference milk thistle plant. Plant samples were dried at 65$^o$C and analysed for total N using a Kjeldahl digestion. $^{15}$N analysis was done using the method described by Doughton et al (2).

*Nitrogen derived from the atmosphere (%Ndfa)*

%Ndfa by chickpea was calculated using the following equation (3).

$$\%Ndfa = 100 \times \frac{\delta^{15}N\ (reference\ plant) - \delta^{15}N\ (legume)}{\delta^{15}N\ (reference\ plant) - B}$$

where $\delta^{15}N$ reference plant and $\delta^{15}N$ legume are the per ml $^{15}N$ enrichment of N in milk thistle and chickpea tops respectively and B is the $\delta^{15}N$ of fixed N for chickpea. A 'B' value of -2.10 for chickpea tops was used in the equation (2).

*$N_2$ fixed*

The amount of $N_2$ fixed was calculated using chickpea crop N yield (kg $ha^{-1}$) and %Ndfa by chickpea as follows:

$N_2$ fixed (kg/ha) = N yield (kg/ha) x <u>%Ndfa</u>

100

RESULTS

*Nitrogen accumulation*

The highest N accumulation was 117 kg N/ha in the 8 June 1993 planting, with 28 April and 21 July plantings accumulating 89 and 76 kg N/ha respectively. The influence of planting time on grain N accumulation followed a similar trend in both years. In 1993 the late winter planting times accumulated a mean 38 kg N/ha compared with 64 kg N/ha for earlier planting times. N accumulation was affected by tillage practice, resulting in a 50% greater N accumulation from ZT (66 kg N/ha) than from CT (44 kg N/ha) (Table 1).

Table 1. The effect of planting time and tillage practice on $N_2$ fixation and N balance in 1993

| **Planting Time** | **Tillage Practice** | **Nitrogen Fixed** | **Grain N Export** | **Soil N gain** |
|---|---|---|---|---|
| | | ---------------------------kg N $ha^{-1}$ | ------------------------- | |
| 28 April | CT | 32 | 34 | -2 |
| | ZT | 27 | 79 | -52 |
| 8 June | CT | 19 | 67 | -48 |
| | ZT | 15 | 74 | -59 |
| 21 July | CT | 15 | 30 | -15 |
| | ZT | 23 | 45 | -22 |
| l.s.d. (P = 0.05) | | n.s. | 31.0 | 55.2 |

*Nitrogen fixation*

The 1992 and 1993 autumn planting values of %Ndfa (12-16% and 14-31% respectively) were low. The amount of $N_2$ fixed in 1993 ranged from 30 kg N/ha for the 28 April planting to 17 and 19 kg N/ha for the 8 June and 21 July plantings respectively (Table 1). There was no significant effect of tillage practice on nitrogen fixation and no planting time x tillage interaction.

*Nitrogen balance*

The resultant loss to soil N, after grain removal, from growing chickpea ranged from 2 to 59 kg N/ha with the amount of loss dependent on time of planting and tillage practice (Table 1). Grain harvest from ZT removed more N than from CT practice and therefore it had more soil N loss.

## DISCUSSION

*Nitrogen accumulation*

In chickpea, as in other grain legumes, N accumulation is closely linked to biomass accumulation (2). A similar relationship is evident in this study. Low available soil water in this study appears to have had a major influence on biomass accumulation and subsequently on N accumulation. Planting time influenced N accumulation in 1993 but not in 1992. The late winter planting times were least favourable for N accumulation in both years. The planting time x tillage interaction was significant for ZT at the 28 April planting time and was probably due to the availability of significantly more soil water between 60-90 cm depth. Chickpea would be able to utilise this water to accumulate greater biomass and N. A close relationship exists between moisture supply, biomass yield and N accumulation in chickpea (4). Beech and Leach (4) found that chickpea accumulated 38 kg N/ha in a below average rainfall year and 177 kg N/ha in an above average rainfall year.

*Nitrogen fixation*

The limited amount of $N_2$ fixed by chickpea in this study compared to other studies (5, 6), was due to high soil $NO_3$-N levels and low plant biomass. Preplant soil $NO_3$-N in this study was high with a mean value in the root zone (0-120 cm) of 162 kg N/ha in 1992 and 110 kg N/ha in 1993. $N_2$ fixation, estimated from other results based on soil $NO_3$-N at planting (2), could be expected to be 55-60 kg/N ha in 1992 and 65-70 kg N/ha in 1993. Amounts fixed were considerably lower at 12-14 kg N/ha in 1992 and 15 - 32 kg N/ha in 1993.

The general relationship between $N_2$ fixed and soil $NO_3$-N, as observed by Doughton et al (2), was similar for this study, with less $N_2$ fixed at higher soil $NO_3$-N levels than at lower soil $NO_3$-N levels. The low values of $N_2$ fixed in our experiment can be attributed to lower total plant biomass produced in dry seasons and differences in available soil water between the two trials. The study reported (2), was conducted near Toowoomba, south east Queensland (annual average rainfall 960mm, potential evapotranspiration - PET 1227mm) in average to wetter than average seasons in the mid 1980's. The study reported here was conducted at Warra, 150 kms further west (annual average rainfall for the trial site of 680 mm, PET 1700 mm) in below average rainfall seasons. Thus the biomass produced and the level of $N_2$ fixed for a particular value of soil $NO_3$-N may decrease as rainfall decreases and PET increases. The fact that there is no tillage effect or interaction of planting time and tillage on $N_2$ fixation is probably also due to the overriding influence of high soil $NO_3$-N in minimising expression of other effects in a season that predisposes the crop to low $N_2$ fixation.

*Nitrogen balance*

The simple N balance presented in Table 1 assumes that the major N input is from atmospheric $N_2$ fixation and the major outputs are in grain. It takes no account of the contribution of chickpea residue and chickpea roots to organic soil N or processes in the soil such as, $NO_3$ leaching, denitrification, ammonia volatilization or non-symbiotic $N_2$ fixation. The negative nature of the N balance however, is of concern in the long term maintenance of an adequate N level in the soil for subsequent crops. Dry seasonal conditions, low biomass production in chickpea and high soil $NO_3$-N have all resulted in low $N_2$ fixation.

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