Effect of sowing date, nitrogen and rhizobium inoculation on flowering and development of yield in chickpeas

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Abstract

Kabuli chickpeas (*Cicer arietinum* L.) were sown on 3 July and 30 September 1992 into a Templeton silt loam soil. Nitrogen at 0, 15, 45 and 90 kg/ha and *Rhizobium* inoculation at 0 and 2 times the recommended rate were applied in a factorial design. Data were collected from plots which had received 0 and 45 kg N/ha and on those which had received 0 and twice the recommended rate of inoculant. Seed yield averaged 305 g/m^2. Nitrogen did not increase seed yield, but it did significantly decrease mean seed weight. In the July sowing inoculated plants which had not been treated with nitrogen produced 423 g/m^2 of seed. Inoculation increased mean seed yield by 44% through increasing the number of pods/plant and seeds/plant. Yield development was affected by sowing date. At one month after flowering plants from the early sown plots had 38% more pods than in the late sowing. However, the early sowing had a large decline in pod number from two months after flowering (41.9 pods/plant) to harvest (31.3 pods/plant). The late sowing had no such decline and had 26.1 and 30.0 pods/plant respectively at the equivalent dates. The only factor which affected phenological development was sowing date. The early sowing flowered at 139 days while the late sowing took only 72 days to flower. Potential yield sites at 50% flowering were affected by the treatments, with 45 kg N/ha producing 8.8 flowering nodes/plant while 0 kg N/ha plants had only 6.3. The early sowing also had a significantly higher number of flowering nodes (9.0) than the late sowing (6.1).

Additional key words: *Chickpea,* Cicer arietinum, *harvest index, inoculation, nitrogen, phenology,* Rhizobium, *yield components.*

Introduction

Chickpea (*Cicer arietinum* L.) is an annual grain legume crop grown primarily for its high protein content, both in quantity and quality (Jambunathan and Singh, 1990). It is cultivated mainly in the Indian sub-continent, but is now gaining popularity in other countries around the world.

Chickpea has the potential to become a new pulse crop in the Canterbury region, where it could provide an alternative crop in the rotation with cereals. Research by Hernandez and Hill (1983, 1985) and McKenzie *et al.* (1992) has shown that chickpeas can be successfully grown in this region and produce high seed yields. However, as is common with many grain legumes, chickpea yield is very variable (Hernandez, 1986).

To stabilize harvest index (HI) and yield it is important to understand the factors that affect flowering and yield development in the crop. Almost no research has been reported in this area (Rahman *et al.*, 1992).

The experiment reported here was aimed at studying the effect of sowing date, nitrogen fertilizer and inoculation on the development of flowering and yield components of chickpeas in the field.

Materials and Methods

The experiment was sown on a Templeton silt loam soil (New Zealand Soil Bureau, 1954) previously in pasture. It followed a randomised split plot design, the main plots being sowing dates and sub-plots being nitrogen and inoculation treatments. A MAF soil quick test gave the following results: pH 6.1, Ca 14, K 16, P 26, Mg 24, Na 4 and S 2. Apart from the experimental treatments no additional fertilizer was applied.

Weed control was with two applications of Cyanazine at 1.7 kg a.i./ha applied at both pre-sowing (seven days before) and pre-emergence (seven days after). From then on weeds were kept to a minimum by hand weeding.

Locally obtained Kabuli chickpea seed, with a 1,000 seed weight of 450 g and a germination of 60% was sown to produce a plant population of approximately 45 plants/m^2. Seed was treated with the fungicide Apron (a.i. metalaxyl 350 g/kg and captan 350 g/kg) at 200 g/100 kg seed to control *Fusarium* wilt and *Ascochyta* blight. There were 2 sowing dates, 3 July (winter) and 30 September (spring) and 4 levels of nitrogen fertilizer 0, 15, 45 and 90 kg/ha, which was supplied as calcium ammonium nitrate (27% N), and broadcast just before sowing. Inoculation was with *Rhizobium cicerii* strain CC1192 at two rates, 0 and twice the recommended dose (480 g/100 kg seed).

The phenological development of each crop was monitored for the 0 and 45 kg/ha and *Rhizobium* treatments from sowing, and recorded at two day intervals from the start of flowering. Phenological stages recorded were emergence, flowering, green pod, expanded pod, mature pod and harvest maturity. When 50% of the plants in any plot being observed had at least one flower, then this was designated as the flowering stage. This standard was maintained for all other stages recorded.

The flowering pattern and yield development of the crop was studied by taking destructive samples. Five plants/plot were used initially, but because of time constraints this number was reduced to 3 plants/plot. These samples were taken weekly from the start of flowering to harvest maturity. Seed yield was recorded from sub-samples of 5 plants/plot at final harvest, which was 75 days after flowering for each sowing.

Results

Climate

Temperature and rainfall during the growth of the crop are shown in Figure 1. The 1992-93 winter and spring seasons were very atypical of the Canterbury region, both being exceptionally cold and wet. The 50 year average monthly rainfall for August, September, October and April is 62, 47, 49, and 56 mm respectively, which when compared to that of the experimental season is much lower (Fig. 1). Similarly, maximum and minimum air temperatures for December, January and February during the experimental season were about 3^{0}C lower than the monthly 50 year average.

Phenological Development

The only treatment that had any significant effect on the phenological development of the chickpea crop was sowing date ($P < 0.001$). The winter sown crop took considerably more time to reach all of the growth stages. Among all the stages monitored, the largest gap of two months between the sowing dates was at the mature pod stage. However, there was an average of a 1 to 1.5

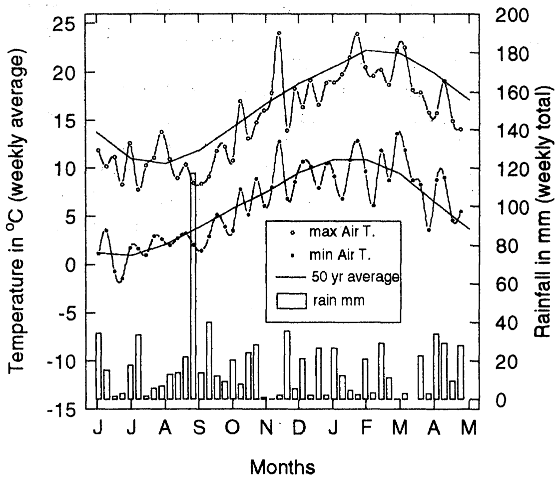

Figure 1. Mean weekly and 50 year monthly average maximum and minimum air temperatures, and weekly total rainfall at Lincoln during the duration of crop growth (1992-93 season).

Table 1. The effect of sowing date on the number of days for 50% of the sampled chickpea plants to reach each phenological stage.

	Days to reach				
Factor	Emergence	Flowering	Green pod	Expanded pod	Mature pod
Winter sowing (3 July 1992)	40	138.8	151.3	156.4	215
Spring sowing (30 September 1992)	17	71.8	85.3	93.9	137
Significance	ns	p<0.001	p<0.001	p<0.001	ns
SEM	-	0.54	0.354	0.37	-
CV%	-	1.4	0.8	1.4	-

months difference at all stages (Table 1.) The winter sown crop took an average of 58.6 days for seed filling (i.e., from the expanded pod stage to the mature pod stage), whereas the spring sown crop took only 43.3 days.

Flowering

The first flowers to form appeared on the main stem. However, the first flowering node on the main stem was not affected by any of the treatments and was located, on average, at node 13.5.

The effect of treatments on flowering nodes/plant was recorded at flowering (50% plants with flowers), one month after flowering and two months after flowering. At flowering, 45 kg N/ha significantly increased the number of flowering nodes/plant from 6.3 in control plants to 8.8, an increase of 28% ($P < 0.01$). Similarly, the winter sown crop had a significantly ($P < 0.05$) greater number of flowering nodes (9.0) than the spring sowing (6.2) at this stage. One month after flowering this trend was still evident with the winter crop having 18.0 flowering nodes/plant and the spring crop 9.0 nodes/plant.

Two months after flowering the average number of flowering nodes on the winter sown plants was 13.5 and in the spring sown crop at the same stage it was only 2.4. However, by this time the winter and spring crops were well into the expanded pod stage and the flowers that were formed at that stage were not expected to contribute to total seed yield.

Yield Components

Only sowing date had a significant effect ($P < 0.01$) on the total number of branches/plant (Table 2). The spring sown crop had 8.16 branches while the winter plants only had 6.38. Thus the spring sowing produced 21.8% more branches than the winter sown crop (this figure includes both primary and secondary branches). However both the branches and pods in the spring crop were smaller than in the winter crop. At final harvest, the number of pods and seeds/plant were significantly affected ($P < 0.05$) only by inoculation. They were increased from 25.8 to 32.8 and from 21.9 to 32.1 respectively. The only factor that had a significant ($P < 0.01$) effect on mean seed weight was nitrogen, which decreased seed weight from 219 mg to 174 mg (Table 2).

However, during crop growth sowing date had a significant effect on the number of pods/plant. At one and two months after flowering the winter sown crop had more pods/plant (34 and 42) than the spring crop (21 and 26), but by final harvest there were no significant differences in pod number between the two sowing dates (Table 2).

Table 2. Effect of sowing date, inoculation and nitrogen on yield components and seed yield of chickpeas.

	Branches/plant	Pods/plant	Seeds/plant	Mean seed weight (mg)	Seed yield (g/m^2)
Sowing date (S)					
July	6.38	30.98	26.2	196	293
September	8.16	27.56	27.9	196	317
Significance	p<0.01	ns	ns	ns	ns
SEM	0.12	1.42	1.31	17.0	2.42
Inoculation (I)					
nil	7.28	25.76	21.98	196	250
I	7.26	32.78	32.12	196	360
Significance	ns	p<0.05	p<0.01	ns	p<0.05
SEM	0.542	1.88	2.04	10.0	5.54
Nitrogen (N)					
nil	7.18	29.02	27.00	219	335
45 kg N/ha	7.36	29.52	27.10	174	275
Significance	ns	ns	ns	p<0.01	ns
SEM	0.542	1.88	2.04	10.0	5.54
Significant interactions	nil	nil	nil	nil	nil
CV %	25.8	22.2	26.1	18.0	31.4

Seed Yield

Seed yield was significantly increased (+ 44%) by inoculation, from 250 to 360 g/m^2, (Table 2). However neither sowing date nor nitrogen affected seed yield and there were no significant interactions.

The harvest index (HI) was significantly reduced from 0.45 to 0.40 by 45 kg N/ha. There was a significant interaction between sowing date and inoculation ($P < 0.05$) (Table 3). In the July sowing the HI for the uninoculated plants was 0.37 and in plants which had been inoculated it was 0.44, whereas in spring sown plants the HI for both the inoculated and uninoculated plants was 0.44. Thus inoculation increased HI in the winter sowing but had no effect in the spring sowing.

Table 3. The inoculation by sowing date interaction for harvest index in chickpeas.

	Inoculation	
Sowing date	nil	2x
Winter (3 July 1992)	0.37	0.44
Spring (30 September 1992)	0.44	0.45
SEM	0.0154	
CV %	7.3	

Discussion

The seed yield from this high value crop was more than 3.5 t/ha (plot yield, 360 g/m^2). The increase in yield due to seed inoculation stresses the importance of ensuring that *Rhizobium* is applied. Hernandez and Hill (1983) reported a similar increase in yield in response to inoculation. However, contrary to their results inoculation did not significantly increase the number of branches/plant.

Inoculation had a significant effect on the number of pods and seeds/plant, HI and total seed yield. This effect of *Rhizobium* on increasing seed yield in chickpea has previously also been observed by Hernandez and Hill (1983) and Beck (1992). There was also an indication that, by increasing seed yield and the number of pods/plant, inoculation might have reduced flower and pod abortion. The significant interaction between sowing date and inoculation shows that inoculation increased HI in winter sown plants (Table 3). This suggests that the inoculation treatment might have been more effective in the winter sown plants than in the spring sowing, possibly because heavy spring rainfall removed nitrogen from the soil, leaving the winter sown inoculated plants better able to cope by fixing nitrogen than the spring sown inoculated plants, where the nitrogen fixation system was not as well established. However, this was not determined.

Sowing date had a major effect on phenological development of the crop. Although the spring sown crop produced more branches/plant throughout the growing season, both plants and branches in this sowing were small. Many branches did not produce sufficient reproductive nodes to bear flowers, because of a shorter growing season. Larger plants are expected to have more potential reproductive nodes than smaller ones (Summerfield *et al.*, 1984) Therefore, the number of flowering nodes/plant was greater in the winter sowing than in the spring sowing. This trend followed through to the number of pods/plant at one and two months after flowering. However, by the final harvest there was no difference in the number of pods/plant between the two sowing dates because around 25% of the pods in the winter sown crop had aborted. The reason for this is not known, but may be related to the unfavourable climate which was exceptionally wet and cold, compared to the 50 year average air temperatures and precipitation in the Canterbury region. There was more cloud and therefore less light, rainfall was higher and temperatures colder. Saxena (1987) has indicated that chickpeas cannot tolerate excess moisture.

Generally in a Canterbury type environment, chickpeas would be expected to increase their yield components and therefore yield when sown earlier (winter). This is because the plants have a longer growing season and can take full advantage of winter rains (Hernandez, 1986; Poma and Fiore, 1990; Mazid, 1992). In this experiment the spring sown crop encountered a moist summer and therefore yielded as well as the winter sown crop. This suggests that a spring sown chickpea crop in Canterbury is capable of producing as much as a winter sown crop, provided there is adequate irrigation. This is advantageous from a farmer's point of view. If equally high yields can be obtained from later sowing of chickpeas, then the land can be used for grazing for longer, or sown to another crop over winter.

The application of 45 kg N/ha had no effect on the number of branches/plant. At the time of flowering nitrogen increased the number of flowering nodes/plant, but after that it had a consistent negative effect on all aspects of crop growth. This may have been because while 45 kg N/ha was sufficient for the crop during its initial growth, in the seasonal conditions the nitrogen was used or leached out of the soil profile due to the heavy rain. At this stage the crop would be left lacking in N as it did not have a well developed nodule system. Nitrogen can suppress rhizobial activity and thus nodulation in chickpeas (Stokes, 1991, Kosgey *et al.*, 1993). When no nitrogen was applied, the *Rhizobium* bacteria applied were apparently able to fix sufficient atmospheric nitrogen for crop use.

Conclusions

1. In a season of abnormally high rainfall, early (winter) sowing gave no advantage. Therefore, even in dry years farmers with irrigation could achieve good yields from spring sowings. There is however, a need to assess further the yield/sowing date response, particularly over a range of spring sowing dates and a dry or warmer winter.
2. Chickpea yield was increased with the application of *Rhizobium*, and HI was increased in the winter sowing but not the spring sowing. There was no advantage from the addition of 45 kg N/ha.
3. In inoculated plots, an indicated seed yield of over 3 t/ha at a current price of approximately NZ$ 2,000/t shows the potential returns possible from this crop, therefore further research is warranted.
4. Pod abortion was high in the winter sowing. The causes of this potential yield loss need further investigation. It is also necessary to make a further study in which individual plants are monitored throughout their growth to measure the extent of flower and pod abortion, its timing and also the parts of the plant that contribute most to final seed yield.

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