EFFECT OF SOWING DATE AND PLANT POPULATION ON GROWTH AND YIELD OF CHICKPEA (*CICER ARIETINUM* L.)

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ABSTRACT

The potential of chickpea as a grain legume crop for Canterbury was evaluated in a field experiment. 'Kabuli' seed was sown at three dates at four-weekly intervals from 27 September to 22 November 1984 to determine optimum sowing date. Four populations ranging from 32 to 80 plants/m² were also included in the investigation.

Differences in dry matter production were closely related to the amount of solar radiation during the growing season, leaf area duration and the efficiency of utilisation of intercepted radiation.

Seed yield decreased from 270 to 206 g/m² as sowing date was delayed. Reduction in seed yield was associated with reductions in the number of branches, pods and seeds per plant. A population level of about 32 plants/m² appeared to be adequate for optimum seed yield.

Additional Key Words: *yield components, radiation interception, leaf area duration*

INTRODUCTION

In the Canterbury area, grain legumes like *Pisum sativum* and *Vicia faba* are traditionally spring-sown in rotations after cereals. In recent years, alternative crops have been tested and there is increased interest in growing crops like navy beans, lupins and lentils. A recent addition to the list of potential alternative crops in the rotation is the chickpea (*Cicer arietinum,*), the third most widely grown pulse crop in the world.

Chickpea is an annual legume crop and is grown at different times of the year in various countries depending on the local climate and the incidence of pests and diseases. For a number of countries and areas, sowing date has been established in relation to temperature. An extensive review by van der Maesen (1972) revealed that chickpea is a spring crop in the Mediterranean region, a summer crop in Iran and Afghanistan, and a 'rabi' (cool winter period) crop in India and Pakistan.

Substantial yield increases are possible by winter sowing as many cultivars are not seriously inhibited by cold (Saxena, 1979; Hawtin and Singh, 1984). However, humid winter conditions encourage the development of *Ascochyta* blight which can often cause complete crop failure (Keatinge and Cooper, 1983). Thus, spring sowing has generally been retained and will probably remain until substantial progress is made in selecting disease-resistant chickpea lines.

Initial research in Canterbury (Hernandez and Hill, 1983) showed that summer-sown 'kabuli' chickpeas produced seed yields (2.08 t/ha) similar to, or better than, those obtained overseas. In Queensland, Australia, where both the 'desi' and 'kabuli' types are commercially grown, the latter type yields only about 1.5 t/ha in dryland and 2.0 t/ha under irrigation (Rettke and Keys, 1985).

Numerous studies in chickpea-growing areas have established the significance of sowing date on crop growth and yield. For example, Ageeb and Ayoub (1976) found that high mean maximum temperature and low relative humidity in the Sudan led to excessive sodium accumulation in plant shoots and resulted in seedling death. Surviving plants sown outside of the optimum period showed poor vegetative and reproductive growth and thus gave low seed yield. Keatinge and Cooper (1983) established a strong relationship between extractable moisture and crop productivity in winter- and spring-sown chickpea crops in Northern Syria.

The experiment reported in this paper was carried out to examine the effects of sowing date on the growth and productivity of chickpeas under Canterbury conditions. Population treatments were also included to confirm the results from an earlier experiment (Hernandez and Hill, 1983).

MATERIALS AND METHODS

The experiment was conducted on a Templeton silt loam soil (N.Z. Soil Bureau, 1968) previously sown in Tama ryegrass. An MAF soil quick test gave the following results: pH 6.1, P (Olsen) 12, Ca 13, K 8, and Mg 12. Phosphate fertilizer at the rate of 25 kgP/ha was broadcast and incorporated into the soil before sowing. Treflan at 2.5 kg a.i./ha applied as a pre-emergent herbicide on 11 September 1984 provided good weed control up to 6 weeks after sowing. Thereafter, weeds were kept to a minimum by handweeding.

Seed of 'kabuli' type cv. Asia was sown at four-weekly intervals on 27 September, 25 October and 22 November 1984, at populations of 32, 48, 64 and 80 plants/m². A 3 x 4 factorial randomised block design with four replicates was used. Plot size was 2.0 x 10.0 m with rows 15 cm apart.

Seed was treated with Benlate 50 and Apron 35 WPs at 2.0 g/kg seed for control of *Fusarium* wilt and *Ascochyta* blight. Marble chips treated with *Rhizobium* strain CC1192 were drilled with the seed at 40 kg/ha.

For further protection against fungal pathogens, the trial area was sprayed with Chlorothalonil + Benomyl at 2.5 and 0.5 kg a.i./ha, respectively, one month after emergence of each sowing. Metasystox at 600 ml/ha was also applied in early November for the control of aphids. No irrigation was applied.

Measurement of seedling emergence, plant population and flowering was carried out on a staked 1.0 m^2 area in each plot. Dry matter production was determined fortnightly by sampling an area of 0.2 m^2 from the middle six rows of each plot. Green leaf area, including all parts of the plants capable of photosynthetic activity, was measured with a photo-electric area meter (Li-Cor Model 3100).

Radiation transmission was measured fortnightly in each plot using tube solarimeters (Delta-T Devices, Cambridge, England) with a three- channel integrator (Szeicz, 1965). Measured solar radiation interception was converted to equivalent absorbed photosynthetically active radiation (PAR)(Gallagher and Biscoe, 1978).

Crop performance was examined by relating dry matter production to green area index and absorbed PAR. Growth efficiency was calculated as the ratio of the calorific value of the crop (assumed here at 18.0 KJ/g) (van der Maesen, 1972: Lieth, 1975) to total PAR absorbed. Partitioning efficiency was the ratio of seed yield to maximum total dry matter production.

At maturity (between 24 January and 21 February 1985), an area of 0.9 by 3.0 m from the centre six rows of each plot was manually harvested and machine threshed for yield determination. At the same time, 20 plants were taken at random from each plot for measurement of yield components.

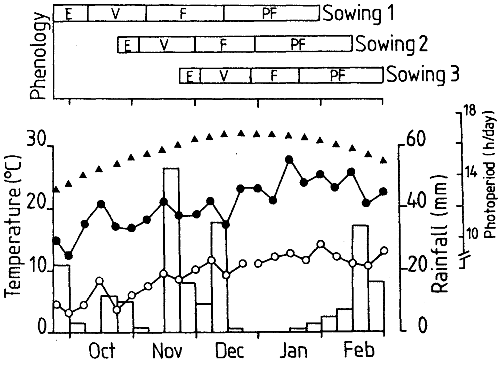

Figure 1: Mean weekly maximum (●) and minimum (o) air temperature, total weekly rainfuall (vertical bars) and mean weekly photoperiod (△) at Lincoln College during duration of crop growth. The time to 50% emergence (E), vegetative (V), flowering (F), and post-flowering (PF) periods are also shown.

RESULTS AND DISCUSSION

Climate Data

The weather from the end of September to December was typical of Canterbury conditions (Figure 1). It was however slightly warmer and drier in January and February. Rainfall for the whole growing season was about 12% below the 51-year average. The average photoperiod of 15.6 h/day was well within the range favourable for crop's growth and development (van der Maesen, 1972). Calculated soil moisture deficit based on the method of Ritchie (1972) is shown in Figure 2.

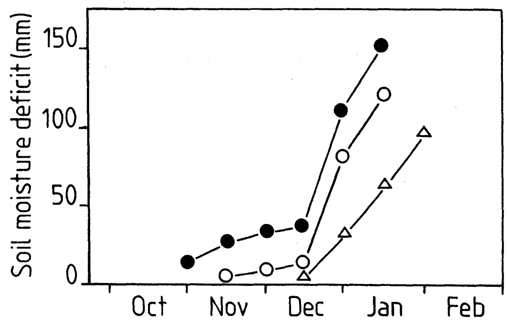

Figure 2: Calculated soil moisture deficit based on Ritchie (1972) during the 1984-85 growing season. Sowing 1 (●), Sowing 2 (o), Sowing 3 (△).

Phenological Development

A good crop establishment was achieved in each sowing date. The time to 50% emergence was reduced by 7 days as temperature rose from 9 to 16°C (Figure 1). Similarly flower initiation was earlier and duration of flowering was shorter in November than in September sowing. Controlled environment studies (Summerfield *et al.* 1980) suggest that these phenological events are induced by longer days and warmer temperatures.

The number of days to maturity decreased as sowing date was delayed. As a result, plant size was markedly reduced. September-sown plants reached a mean maximum height of 45 cm and were 11 cm taller than the November-sown plants. Similarly, early-sown plants had significantly more branches and higher total dry weight than the later sown plants.

Canopy Development

Changes in green area index (GAI) with time (Figure 3) provide visual integration of changes in environmental conditions typical of the Canterbury region. Rates of green area development were slow in late October to mid-November when temperatures were low. However, as temperature rose, rapid rates of development occurred. Growth stimulation due to increased temperature had earlier been demonstrated for chickpeas (Eshel, 1967; Summerfield *et al.*, 1980). Maximum GAI for the September-sown crop was achieved in mid-December, approximately 70 days after emergence. In contrast, the

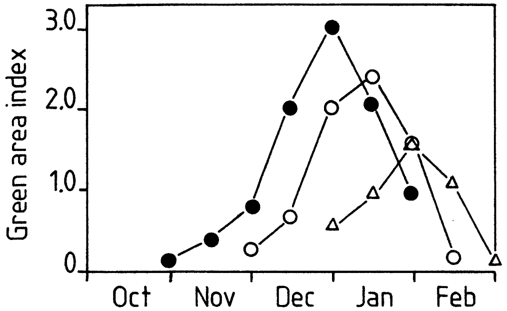

Figure 3: Effect of sowing date on canopy development Sowing 1 (●), Sowing 2 (o), Sowing 3 (△).

November-sown crop took only 56 days from emergence to reach maximum GAI. Thereafter, there was pronounced leaf senescence and the GAI declined rapidly. Ritchie *et al.* (1972) observed that leaf senescence in determinate crops occurs at a certain stage of maturity regardless of the moisture status of the crop. On the other hand, indeterminate crops like chickpea do not senesce during warm weather if the water supply is favourable (Keatinge and Cooper, 1983). In this study, the high temperatures that prevailed in late December to January were accompanied by lack of rainfall (see Figure 1). Thus, whilst high temperatures seemed to have induced rapid canopy development in later-sown crops, it also shortened crop duration. Onset of leaf senescence occurred earlier in the November sowing which was probably due to moisture stress (see Figure 2). This produced a significantly ($p \leqslant 0.01$) lower maximum GAI value of 1.5 compared with 3.1 for the early-sown crop.

A positive relationship between green area development and plant population was observed during the early stages of growth (up to 8 weeks after each sowing) but beyond that the low plant populations were able to compensate by producing more foliage. This response is typical of many legume crops where a high degree of plasticity has been reported over a range of plant population (e.g. Muchow and Charles-Edwards, 1982).

Dry Matter Production

Total dry matter decreased from 581 to 466 g/m² as sowing date was delayed (Table 1). These significant differences strongly reflect those observed in green area development (Figure 3). Keatinge and Cooper (1983) also observed large differences in green area and dry matter production between winter- and spring-sown chickpeas in Northern Syria.

Another major cause of variation in TDM yield was the amount of solar radiation intercepted by each crop (Table 1). The September sowing intercepted a total of 459 MJ/m² of photosynthetically active radiation (PAR) as against 356 MJ/m² for the November-sown crop. A very high correlation (r. = .985**) was found between total dry matter production and absorbed PAR.

TABLE 1: Absorbed radiation, maximum dry matter production, growth efficiency and harvest index as affected by sowing date and plant population.

Factors	PAR absorbed (MJ/m²)	Maximum DM (g/m²)	Growth efficiency (%)	Harvest index (%)
Sowing date:				
27 Sep	459	581	2.36	46
25 Oct	386	563	2.67	46
22 Nov	356	466	2.05	44
Significance	*L	**L	**Q	NS
$S\bar{x}$	6.9	13.4	0.062	1.0
Population (plants/m²):				
32	379	564	2.78	44
48	385	550	2.61	46
64	411	537	2.16	48
80	428	503	1.88	47
Significance	*L	*L	**L	NS
$S\bar{x}$	5.4	15.5	0.071	1.3
Interaction	NS	NS	NS	NS
C.V. (%)	14.2	6.1	10.5	9.3

The September-sown crop produced the highest TDM yield. Total PAR absorbed was high because of its longer growth duration. However, its growth efficiency was only 2.36% compared to 2.67% for the October sowing (Table 1). The most likely explanation for the difference could be the time active vegetative growth took place in relation to incident solar radiation. Radiation was greatest in January when the October-sown crop was actively growing. By this time the September-sown crop was already rapidly senescing. Thus, the greater growth efficiency of the October sowing appeared to compensate for its shorter growth duration. As a result the harvest index was similar (46%) in both sowings. The lowest TDM yield was obtained from the November sowing which had both the lowest PAR absorbed and growth efficiency at only 2.05%. It achieved only a small LAI and its canopy developed too late to intercept the high January incident radiation.

An inverse relationship was observed between TDM and plant population, i.e. dry matter production decreased as population increased (Table 1). This trend was earlier observed in most chickpea cultivars tested by Saxena and Sheldrake (1978). However, while total PAR absorbed was higher at high plant populations, growth efficiency was low. At low populations, plants continued to produce young leaves up to the reproductive period. This was not observed at high populations. The importance of young leaves for photosynthetic activity was stressed by Stewart *et al.* (1978) and their presence could have contributed to greater efficiency. On the other hand, reduced growth efficiency at the higher populations could have been due to light saturation of the canopies over a much longer period.

TABLE 2: Effect of sowing date and plant population on seed yield and yield components in chickpea.

Factors	Seed yield (g/m^2)	No. pods per plant	No. seeds per pod	Mean seed wt (mg)
Sowing date:				
27 Sep	270	21.6	1.10	341
25 Oct	258	17.7	1.08	371
22 Nov	206	15.1	1.05	346
Significance	**L	**L	NS	**Q
$S\bar{x}$	3.7	0.66	0.05	2.0
Population (plants/m^2):				
32	246	27.2	1.08	358
48	254	20.6	1.08	354
64	251	13.8	1.06	351
80	228	10.8	1.08	349
Significance	*Q	**L	NS	NS
$S\bar{x}$	4.3	0.76	0.01	2.0
Interaction	NS	NS	NS	NS
C.V. (%)	7.0	14.5	3.7	2.3

Yield and Yield Components

Seed yield decreased from 270 to 206 g/m^2 as sowing date was delayed from September to late November (Table 2). A previous trial (Hernandez and Hill, 1983) sown in mid-December yielded 208 g/m^2 similar to that obtained in the November sowing.

The significant differences in final yield were closely associated with the variation observed in the vegetative growth (Figure 3) which in turn had a considerable effect on the components of yield. Summerfield *et al.* (1984) observed that heavier chickpea plants had more potential reproductive sites (nodes) than smaller ones. Table 2 indicates that September-sown plants were significantly bigger and heavier, and produced more pods. The significantly ($p < 0.01$) higher number of pods per plant produced in the September sowing was probably a direct consequence of a higher number of primary and secondary branches bearing more fertile nodes. Seed yield reduction in soybeans (Board, 1985) grown at non-optimal dates was also found to be associated with decreased branch number which produced fewer fertile nodes.

Seed yield per unit area showed a quadratic response to population treatments (Table 2). Maximum yields were obtained from 32 to 64 plants/m^2, similar to those reported in our earlier experiment (Hernandez and Hill, 1983). In both these studies however, the yield difference between 32 and 64 plants/m^2 was trivial and would suggest that 32 plants/m^2 is adequate for optimum seed yield. Results of several studies in India indicate that the optimum plant population for chickpea is about 33 plants/m^2 (Saxena, 1980).

The number of pods per plant was the yield component most affected by density stress (Table 2). Siddique *et al.* (1984) observed a similar trend resulting from fewer pods on later formed branches at high density. The number of seeds per pod was not affected by any of the treatments but a quadratic response to sowing date was observed in mean seed weight (MSW). Late-sown crops have been reported to produce seeds with lower MSW (Saxena and Sheldrake, 1978) probably due to water stress during the reproductive period as found in cowpea (Summerfield *et al.*, 1976) and soybeans (Constable and Hearn, 1978). On the other hand, the lower MSW of the September-sown crop could have been due to the limited supply of assimilates in the later formed pods (Sheldrake and Saxena, 1979).

CONCLUSION

Results from this experiment in conjunction with our earlier work (Hernandez and Hill, 1983) indicate the potential of chickpea as a new grain legume crop for Canterbury. Crop performance based on date of sowing indicates that increased total dry matter production, which is the major requirement for high seed yield, can be achieved by planting in late September. Productivity of later-sown crops should be reduced from potential levels by soil moisture stress.

A population level of about 32 plants/m^2 appeared to be adequate for optimum seed yield. However, further work is needed particulary in relation to the water requirements of the crop.

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