EFFECT OF PLANT POPULATION ON SEED YIELD AND YIELD COMPONENTS OF FIELD PEAS

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ABSTRACT

Field trials were sown in October 1977 under dry land conditions on a Templeton silt loam at Lincoln College, Canterbury to compare the new field pea cultivars Huka and Whero at five plant densities ranging from 25 to 163 plants m^{-2}.

Huka, a wilt resistant replacement for White Prolific and Pamaro, consistently produced more pods and branches per plant and had a greater seed yield at all plant densities than the maple pea Whero. However, Whero produced larger, heavier (250 mg) peas than Huka (234 mg). There was no significant difference in pea dry weight within either cultivar with increasing plant density, but all other yield components showed a decrease. No significant difference occurred between cultivars for number of peas per full pod.

Yield of dry peas followed an asymptotic response to increased density for Huka and a parabolic response for Whero. The yield of Huka reached 4120 kg ha^{-1} at 47 plants m^{-2} and did not increase significantly beyond this population. Similarly, Whero yielded 3170 kg ha^{-1} at 48 plants m^{-2} and reached a peak of 3480 kg ha^{-1} at 89 plants m^{-2}, but this increase was not significant.

It would appear that both cultivars could be sown in Canterbury at somewhat less than the normal rate of 200 kg ha^{-1} (approximately 70 plants m^{-2}) without significant yield reductions and with considerable savings in seed cost.

INTRODUCTION

Little research has been conducted in New Zealand on the optimum plant populations for field peas. Most effort has been concentrated on garden peas grown for vining (Sheath 1972; White and Anderson 1974; Anderson and White 1974; Stoker 1975) where crops grown under irrigation were shown to require a higher plant population (135 plants m^{-2}) for optimum yields than those grown on dry land (80 plants m^{-2}). There is also some indication (Anderson and White 1974) that vining peas need to be sown at a higher population than those grown for seed.

The recommended sowing rates for maple, blue and white peas vary considerably, according to variety and seed size, although Beggs and Barrer (1960) reported that rates between 170 and 200 kg ha^{-1} are most commonly used in this country. The ability of some varieties to produce pod-bearing branches from basal positions may enable them to be drilled at lower rates without significantly depressing yield. In addition, the number of branches per plant has been found to increase with a decrease in population (Reynolds, 1950).

The aim of this experiment was to determine the optimum seeding rates for a white pea (Huka) and a Maple pea (Whero) under Canterbury conditions. Huka, which not only yields better than its predecessor Pamaro (Crampton, 1975) also shows more resistance to pea leaf roll virus. Its white skin and deep yellow cotyledon makes it an ideal candidate for our split pea and pea flour export market. Whero, also bred at the Crop Research Division, D.S.I.R. was released for multiplication last year. Its resistance to pea top yellows and pea mosaic viruses, its earlier maturity, determinate growth habit and generally higher yield of larger more even seed give Whero several advantages over Partridge '73 (Scott R. E. pers. comm.)

Both Huka and Whero branch freely and it was felt this may be an important factor in determining the correct plant population to establish.

MATERIALS AND METHODS

The trial was carried out at Lincoln College on a Templeton silt loam previously in lucerne. The two field pea (*Pisum sativum*) cultivars, Huka and Whero, were drilled in 15 cm row spacings on October 14, 1977 in plots measuring 1.5m x 20.0m. Five populations, replicated three times were established as follows:

*Huka: 25, 47, 103, 108 and 163 plants m^{-2}
*Whero: 27, 48, 89, 108 and 155 plants m^{-2}
(* Populations determined three weeks after sowing, seedlings 5 cm tall.)

Equivalent sowing rates required to establish these populations were 140, 280, 420 and 560 kg ha^{-1} to give plant populations of 50, 100, 150 and 200 plants m^{-2}.

Seed of Huka was treated with Orthocide and that of Whero with both Orthocide and Streptomycin. A basal dressing of 0.5 t ha^{-1} lime was applied before sowing and 20 kg phosphorus ha^{-1} as flowmaster superphosphate was drilled with the seed. A pre-planting application of 84 g a.i. ha^{-1} of trifluralin provided good annual week control for a period of between six and eight weeks after sowing.

Thirty six days after sowing and when the seedlings were approximately 8 cm tall, every second plant was thinned from three plots of each cultivar to achieve the lowest population. One half of all plots was randomly set aside for the determination of dry seed yield while five subplots were located randomly within the remaining half and in each subplot five plants were colour labelled at flowering.

The following measurements were made on each of these 25 plants, in late January when all plants had developed near-mature pods;

i) Number of pods per plant
ii) Number of peas per pod
iii) Total dry weight of peas per plant

The total number of branches (both productive and non-productive) per plant was counted at flowering and also just prior to maturity.

On January 31, 1978 a 5.0 m^{-2} sample area was selected and vines were carefully hand pulled from the middle six rows, the outer two rows being discarded. The lowest populations of Whero were later maturing and were not harvested until February 6th. After threshing in a mini-viner, all samples were passed over a riddle with 6.75 mm diameter holes which removed most clods and small seed. Seed was weighed and corrected to 14% moisture.

RESULTS

Climate

The season was generally warmer and considerably drier than average. The month of December when most of the plots flowered and pod swelling took place was particularly dry (Table 1).

TABLE 1: Rainfall and mean temperature, Lincoln College October 1977 to January 1978

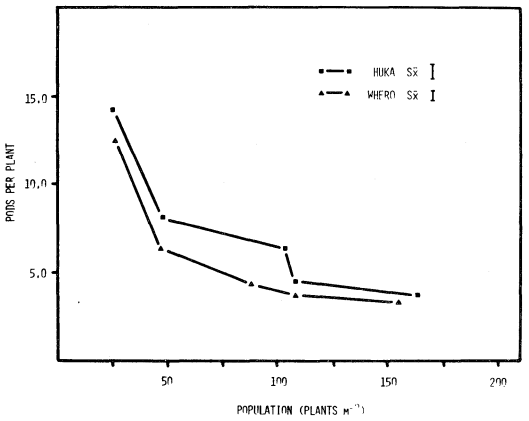
	Month	Rainfall mm	Mean daily air temperature °C
1977	October*	6 (-17)π	12.5 (+1.2)
	November	33 (-18)	12.8 (-0.3)
	December	34 (-23)	15.1 (+0.4)
1978	January**	17 (-11)	16.9 (+0.8)

* Mean figures from 14th October to end of month.
** Mean figures from 1st to 16th January.
π Figures in parenthesis indicate deviation from long term average (1881 - 1974, Lincoln College).

Components of Yield

The mean number of pods per plant decreased with increasing plant density (Fig. 1). Huka, with a

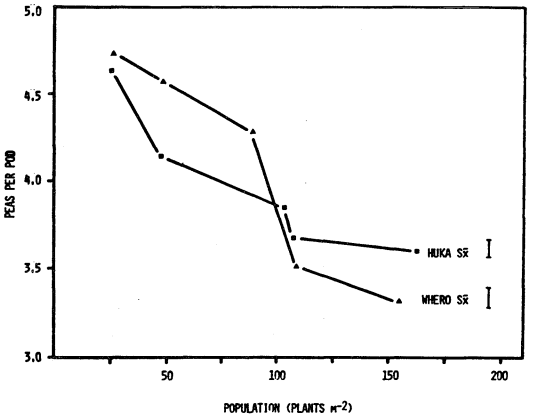
Figure 1: Effect of plant population on number of full pods per plant of Huka and Whero peas



value of 14.2 at the lowest sowing rate and 3.7 at the highest consistently had a higher pod count over the whole range than did Whero with values of 12.5 and 3.4 respectively. This difference between the two cultivars was highly significant.

In a similar way the average number of peas in each full pod was inversely related to plant population (Fig. 2). Although Whero had more peas per pod than Huka at low plant densities a very rapid decline in this component between 89 and 108 plants m^{-2} reversed the situation when inter-plant competition becomes more intense at higher densities. There was, however, no significant difference between cultivars at any particular sowing rate.

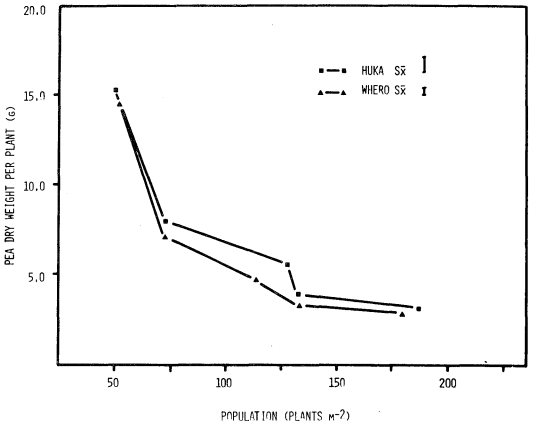
Figure 2: Effect of plant population on number of peas per pod of Huka and Whero peas



Population had no significant effect on individual pea dry weight but Whero was consistantly heavier (Mean of 250 mg pea $^{-1}$) than Huka (Mean of 234 mg).

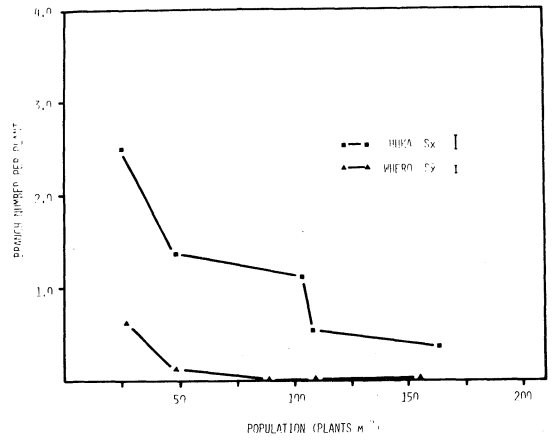
Total pea dry weight per plant (Fig. 3) also declined with increasing density. Huka consistently out-yielded Whero on a per plant basis over the whole range but these differences were not significant.

Figure 3: Effect of plant population on total pea dry weight per plant of Huka and Whero peas



It is evident from Figure 4 that Huka branches more freely than Whero. Even at the highest density, when intra-row spacing of Huka was only 4.2 cm, a mainstem plus a mean at 0.3 branches per plant were produced. Branching in Whero dropped off rapidly to the point where just a mainstem grew at a density of

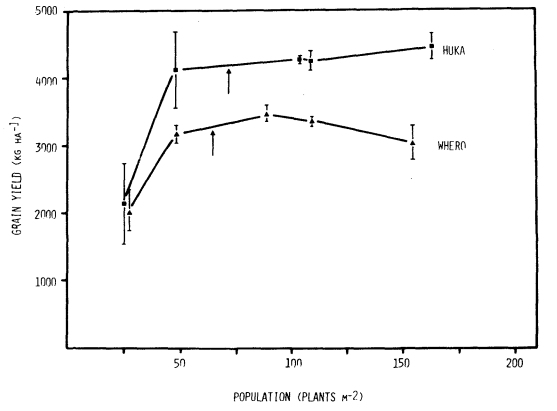
Figure 4: Effect of plant population on number of branches per plant of Huka and Whero peas



89 plants m^{-2}, when the intra-row spacing was 8.8 cm. These varietal differences are highly significant. Only at the lowest population did branching of Whero reach a significant level. The data presented in Figure 4 were obtained at the flowering stage of growth. Although both cultivars continued to produce branches between flowering and final harvest, any pods these may have supported generally contained immature peas and could be disregarded.

Figure 5 indicates significant and striking differences in grain yield between cultivars. Whero follows a parabolic response to population but there was no significant increase in yield beyond 48 plants m^{-2} even though a maximum yield of 3480 kg ha^{-1} was obtained at 89 plants m^{-2}. Huka on the other hand appears to follow an asymptotic pattern with a significant increase in yield between 25 and 47 plants m^{-2} but no further increase above this. At 48 plants m^{-2} Huka out-yielded Whero by 950 kg ha^{-1} of machine dressed seed.

Figure 5: Effect of plant population on seed yield of Huka and Whero peas (Arrows indicate yields obtained with the present standard sowing rate of 200 kg ha^{-1})



DISCUSSION AND CONCLUSIONS

It is generally accepted that the two most sensitive stages to water stress in the development of a pea plant are at flowering and pod swelling. Climatic data indicated no rain of any significance fell while the highest populations of both Huka and Whero were flowering. Approximately 7 days and 24 days prior to flowering falls of 7.3 mm and 6.9 mm were recorded respectively. During the pod-swelling period of both cultivars the only significant precipitation was on December 30, when 8.6 mm was recorded. This, accompanied by the occasional strong nor-westerly wind could be expected to place the plants under some degree of water stress. Flowering (December 17) and pod-swelling (January 3) of the lowest population of Whero generally occurred later than any other plots. A rainfall of 10.5 mm just after flower initiation and 11.9 mm during pod-swelling may account for the less rapid decline in yield of Whero between the lowest two populations than occurred with Huka (Fig. 5).

The effect of plant density on components of yield are consistent with those reported by other workers (Sayre 1947; Reynolds 1950; Salter and Williams 1967; Sheath 1972; White and Anderson 1974; Anderson and White 1974) in that pod numbers per plant and peas per pod decreased with increasing density. Although no significant difference was found in individual pea dry weight within each cultivar over the whole range of plant population, when the components peas per pod, pods per plant, and dry weight per pea are combined, the total pea dry weight per plant is obtained (Fig. 3). This result, as could be expected, follows the same trend of decreasing with increasing density. Reynolds (1950) and Sheath (1972) found a similar response with marrowfat and garden peas respectively.

With regard to total yield, it would appear that the large number of plants m^{-2} present at the higher densities compensates for the lower production of pods per plant, number of peas within those pods and total pea dry weight per plant. For Whero the number of peas per pod seems to be more sensitive to increased inter plant competition at high plant densities than with Huka. This may be an important factor in explaining the yield reductions which occurred in these plots with Whero.

Our results indicate that as intra-row spacing is increased branching increases. This is similar to the situation reported by Reynolds (1950). We have found obvious differences between the two cultivars under study and it is suggested that the greater number of pod-bearing branches produced by Huka over the range of treatments is instrumental in achieving the consistently higher yields obtained with this cultivar. As the number of peas per pod does not differ between Huka and Whero and Whero has a higher dry weight per pea, to attain these greater total seed yields Huka has been able to more than compensate by producing more pods per plant. This has been possible by the production of more pod-bearing branches than Whero and is reflected in Huka's higher weight of pea production per plant (Fig. 3).

Branching in peas is thought to be a form of apical dominance and as such is under the influence of

various environmental as well as genetic factors. Branching may be increased by growing plants in high nitrogen status conditions (Gregory and Veale 1957; McIntyre 1964; 1965), by the reduction of water stress (McIntyre 1971) and by short days (Phillips 1969; 1975). On the other hand, fewer branches may be produced when Ca and/or Mg are limiting, by low light intensity (Lockhart 1961; Shein and Jackson 1971; Jackson and Field 1972) or by long days (Phillips 1969; 1975), although both the quantity and quality of light is important here (Field and Jackson 1975). So to stimulate branch production it may be necessary to sow in early spring into fertile soil thus avoiding the effects of long days and water stress which may be encountered with later sowings.

Since this study was commenced similar sowing rate work has been reported by Scott and Hadfield (pers. comm.). Working at Lincoln with spring sown, irrigated Whero they found from three trials that densities of 55, 53 and 30 plants m^{-2} gave yields as good as standard populations (70 plants m^{-2} or more) during the 1976/'77 and 1977/'78 seasons. Yields of 4.7, 3.6, and 3.4 t ha^{-1} were obtained from these populations respectively. In a similar way our work indicates that both Huka and Whero could be sown to achieve populations of around 50 plants m^{-2} before yield reductions occur. The actual sowing rate necessary will depend on both the 1000 grain weight and percent expected field emergence of the variety sown, but indications are that a considerable saving to the Canterbury grower in seed costs may be possible.

The final decision on seeding rates for these two varieties will also be affected by environmental factors such as rainfall, irrigation, or soil type, as the more favourable the environment, the higher will be the optimum population. Higher plant densities are more likely to suppress weed growth (Monson 1942; Reynolds 1950; Gritton and Eastin 1968; Anderson and White 1974) and this effect was obvious in the trial we conducted.

In conclusion it would appear that there is considerable room for plant population studies to determine optimum sowing rates for seed production of peas in Canterbury particularly with varieties which branch freely.

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