
Optimum Plant Population Density for Chickpea In a Semi-arid Environment

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Abstract

Chickpea (*Cicer arietinum* L.), an annual grain legume, is being rapidly included in cereal-based cropping systems throughout the semi-arid Canadian prairies, but information on optimum plant population density (PPD) has not been developed for this region. This study was conducted from 1998 to 2000 in southwestern Saskatchewan to determine the impact of PPD on field emergence, seed yield and quality, and harvestability of kabuli and desi chickpea compared with dry pea (*Pisum sativum* L.). Seed yields of all legumes increased with increasing PPD when the crops were grown on conventional summerfallow. The PPD that produced the highest seed yields ranged from 40 to 45 plants m⁻² for kabuli chickpea, 45 to 50 plants m⁻² for desi chickpea, and 75 to 80 plants m⁻² for dry pea. When the legumes were grown on wheat stubble, the PPD that gain optimum seed yield ranged from 35 to 40 plants m⁻² for kabuli, 40 to 45 plants m⁻² for desi chickpea, and 65 to 70 plants m⁻² for dry pea. The proportion of large-sized (>9-mm diameter) seed in the harvested seed was >70% when the kabuli chickpea was grown on summerfallow regardless of PPD, whereas the large-seed proportion decreased with increasing PPD when the crop was grown on wheat stubble. Increases in PPD advanced plant maturity by 1.5 to 3.0 days, and also increased the height of lowest pods from the soil surface by 1.4 to 2.0 cm (or 5 to 10%), with desi type receiving the greatest benefits from increased PPD.

Introduction

Chickpea, an annual grain legume, was recently introduced to Canadian prairies and is now being rapidly adopted in the dry Brown and Dark Brown soil zones (Gan and Noble 2000). However, little is known about the growth and development responses of chickpea to changes in plant population density (PPD). In commercial production of chickpea, seed costs are a major input expense, often exceeding CAN \$140 to \$180 ha⁻¹. If a lower seed rate could be used without adverse effects on seed yield and quality, then production costs could be reduced substantially. Conversely, chickpea is a poor competitor with weeds, due to its slow growth during early growth stages, short plant stature (< 60 cm in height), and open canopy. Harvest conditions are particularly important to chickpea production in the Canadian prairies. The average frost-free (OEC basis) period in the chickpea production region ranges from 92 to 120 days, which is critically close to the minimum period required for chickpea to reach maturity. Delayed maturity of chickpea detrimentally influences seed coat colour and grades. Canopy height and the lowest pod height from the soil surface are also crucial for minimizing harvest losses of chickpea. Setting harvest equipment close to the ground to pick up the pods near the soil surface also increases the risk of equipment damage. Furthermore, grain contamination with soil picked up during harvest

can cause chickpea seed discolouration and downgrading. The objectives of this study were to i) determine optimal plant population densities for kabuli and desi chickpea grown in the semiarid Canadian prairie; and ii) evaluate the impact of plant population density on seed yield, proportion of large-sized (9-mm diameter) seeds, and harvestability of chickpea.

Materials and Methods

The experiment was conducted from 1998 to 2000 at two sites in southwestern Saskatchewan. One site was on a Swinton silt loam in Swift Current, and the second site was on Sceptre heavy clay in Stewart Valley. The treatments consisted of three factors: i) chickpea market classes, ii) PPD, and iii) field phases (i.e., conventional summerfallow and wheat stubble). Three market classes of chickpea and one type of dry pea were included: a) large-seeded kabuli chickpea (>Dwelley= and >Sanford= in 1998, >CDC Xena= and >CDC Yuma= in 1999 and 2000); b) small-seeded kabuli chickpea (>B-90' in 1998, >CDC Chico= in 1999 and 2000); c) desi chickpea (>Myles= in all site-years); and d) dry pea (>Carrera=, a semi-leafless cultivar with yellow cotyledons). Dwelley, Sanford, and B-90 have been the most popular cultivars grown in the Canadian prairies, while CDC Xena, CDC Yuma, and CDC Chico are newly registered cultivars. We switched to the newly registered cultivars in the 2nd and 3rd years of the study because these cultivars are agronomically superior and have begun to replace the earlier cultivars (Warkentin, personal communication). Four seeding rates were used to obtain the target PPD of 20, 30, 40, and 50 plants m⁻² for chickpea and 35, 50, 65, and 80 plants m⁻² for the dry pea. Actual seed rates were based on seed size, pre-seed germination, and an estimated field emergence rate of 75%. At each site-year, crop types and PPD were arranged in a factorial, randomized complete block design with four replicates. All treatments were tested at two field phases (on conventional summerfallow and wheat stubble). The two field phases were established side-by-side in the field for ease of field operations.

Seed was treated with 600 ml each of *carbathiin* and *thiabendazole*, and 16 ml of *metalaxyl* per 100 kg of seed. Plots were seeded when soil temperature at a 10-cm depth was between 9 and 13°C. The various seeding rates were accomplished with a 2-m wide hoe press drill equipped with a spinner seed metre. Each plot was 7.5 m long and consisted of 10 rows with 20-cm spacing between rows. Phosphorous fertilizer was applied (as monoammonium phosphate) with the seed at a rate of 7.5 kg P ha⁻¹. All plots received 5.5 kg ha⁻¹ of >Nitragin=, an appropriate soil implant *Rhizobium* inoculant (a granular form) for symbiotic N fixation. The *Rhizobium* inoculant was applied in the seed rows. Weeds were controlled with a comprehensive management program to maintain the overall weed pressure at a minimum level. All plots were sprayed with chlorothalonil at the recommended rate to control ascochyta disease. Data were analysed using the PROC MIXED procedure of SAS.

Results and Discussion

Seed yields of desi and kabuli chickpea increased with increases in PPD from 20 to 50 plants m⁻² when the crops were grown on summerfallow (Fig. 1). The yield response for desi chickpea to PPD was more pronounced than that of kabuli chickpea. The seed yield of dry pea increased with increasing PPD from 30 to 80 plants m⁻² in most cases. However, when the legumes were grown

on wheat stubble, seed yield responses varied among years. In 1999 and 2000, the yield of the legumes increased with increasing PPD, with patterns that were similar to those when grown on summerfallow. However, in 1998, seed yields increased with PPD for desi chickpea, decreased for kabuli chickpea, and were unaffected for dry pea. Spring soil water and growing season precipitation in 1998 were lowest among the 3-study years, causing depressed yields for all legumes. With such dry conditions, kabuli chickpea grown on wheat stubble suffered severe water stress and produced half as much yield as the crop was grown on summerfallow.

The price that producers receive for kabuli chickpea increases as the proportion of seeds greater than 9-mm in diameter increases. For example, kabuli chickpea buyers have offered a premium of 124 per kg (averaged for 1999, 2000, and 2001) for kabuli seeds greater than 9-mm in diameter compared to those 8-mm or less in size. In our study, the seed size fractions varied significantly for kabuli chickpea grown under the different conditions (Fig. 2). For chickpea grown on conventional summerfallow, the proportion of seed that was >9-mm in size was >75% in 1998, >60% in 1999, and >70% in 2000, which were significantly higher than those obtained for the crop grown on wheat stubble in the same years. In general, PPD had a marginal impact on the proportion of 9-mm seeds when the crop was grown on summerfallow; however, there was a significant, linear reduction in 9-mm seed proportion due to increased PPD when the chickpea was grown on wheat stubble, except in 1999 where the effect was not statistically significant.

Days to maturity of the legumes varied widely among years. In 1998, chickpea required 81 to 85 days to mature, while they required 99 to 113 days in 1999, and 103 to 120 days in 2000. Maturity of dry pea followed similar yearly patterns as chickpea, but the dry pea matured 12 to 17 days earlier than chickpea. Higher than normal temperatures in 1998 permitted rapid growth and development, resulting in the earliest maturity for all legumes. In a given year, desi chickpea required similar days to mature as small-seeded kabuli cultivars; both maturing 2 to 3 days earlier than large-seeded kabuli chickpea.

Plant population density had a significant influence on plant maturity (Fig. 3). On average, as PPD increased from 20 to 50 plants m^{-2} , crop maturity accelerated by 2.1 days for large-seeded kabuli, 3.0 days for both small-seeded kabuli and desi chickpeas, and 1.5 days for dry pea. This trend was consistent across the three years. Advanced maturity with high PPD is beneficial for pulses to reduce risks of early fall frost. Earlier maturity and thereby earlier harvest usually translates into a significant gain in seed quality and net returns due to better grades.

The short stature of annual pulses, particularly in years when crop growth is limited by water, is a common problem in the semiarid Canadian prairies. We found that the average height of the lowest pods from the soil surface was >25 cm for large-seeded kabuli chickpea, >22 cm for small-seeded kabuli chickpea, and >20 cm for desi chickpea. PPD had a small but significant influence on the lowest pod height. Lowest pods were furthered from the soil surface for plants grown at higher PPD than for plants grown at lower PPD. For example, as PPD increased from 20 to 50 plants m^{-2} , the lowest pod height increased 1.4 cm for large kabuli chickpea, 1.7 cm for small kabuli chickpea, and 2.0 cm for desi chickpea. The lowest pod height for desi chickpea was 5 cm lower than for kabuli chickpea, but the response to increasing PPD was the greatest (10%).

The economic optimum PPD can be obtained when the margin between the value of grain produced and the cost of production is maximized. Increasing PPD hastens maturity which, in turn, reduces the yield and grade losses from early-fall frosts. Increasing PPD also increases the height of the lowest pod that can potentially reduce both harvest losses and repair costs for harvesting equipment. In addition, PPD influences weed competitiveness that impacts crop yields and requirements for herbicide applications. Increased PPD increases the production costs directly through increased seed cost, seed treatments and handling. Because of the multiple effects associated with PPD changes, coupled with the large variations in seed cost, sale prices, seed size premiums, and the values of early maturity and of the increased pod height, we could not clearly identify economically optimum PPD.

Based on highest seed yields of the several site-years, we have tentatively set the optimum PPD for maximizing seed yields as 40 to 45 plants m^{-2} for desi chickpea, 35 to 40 plants m^{-2} for both large- and small-seeded kabuli chickpea, and 60 to 70 plants m^{-2} for dry pea. Beyond these PPD levels, seed yields will either level off or decrease depending on growing conditions. However, there are three exceptions to these recommendations: 1) For desi chickpea and dry pea grown on summerfallow, grain yield increased linearly over the range of PPD used in the study; further research involving higher PPD is needed to refine the optimal PPD for these two crops grown on summerfallow. 2) For large-seeded kabuli chickpea, the optimum PPD does not correspond to the highest grain yield but would appear to be a reasonable target given the trend towards decreasing the harvested seed size in two of three years (Fig. 2a). 3) For small-seeded kabuli chickpea grown on summerfallow, the optimum PPD appears to be 40 to 45 plants m^{-2} , or 10% higher than those grown on wheat stubble. The increase in seed yields with high PPD was greater than the additional seeds that were needed to achieve the high PPD. Nevertheless, in a growing season with more drought stress occurring, there is risk of diminishing grain yields at high PPD for all crops. Hence, for production of these annual pulses on wheat stubble, we suggest a target seed rate being 10% lower than that needed for production on summerfallow in the same year.

Acknowledgements

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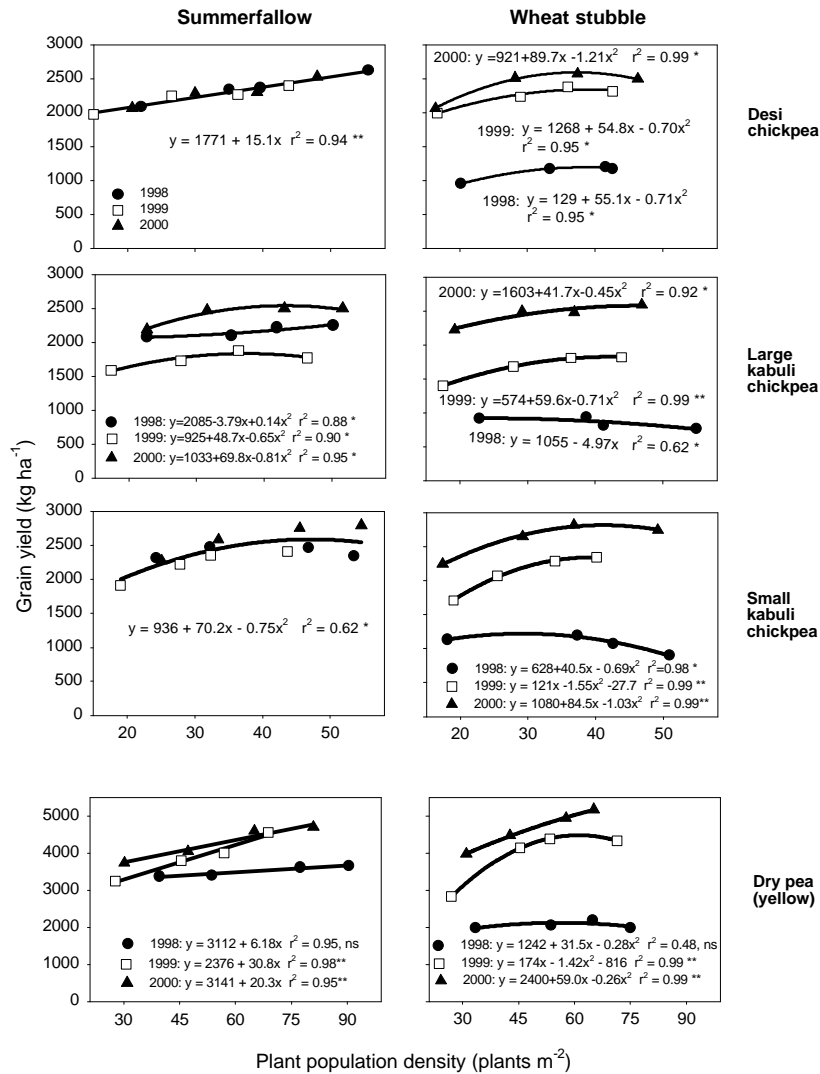


Fig. 1. Seed yields of three market classes of chickpea and dry pea grown on conventional summerfallow and on wheat stubble, with different plant population densities in southwestern Saskatchewan. (Equations with *,** are those whose slopes were significant at $P < 0.05$ and $P < 0.01$ from zero, respectively; ns means the slopes were not significant from zero).

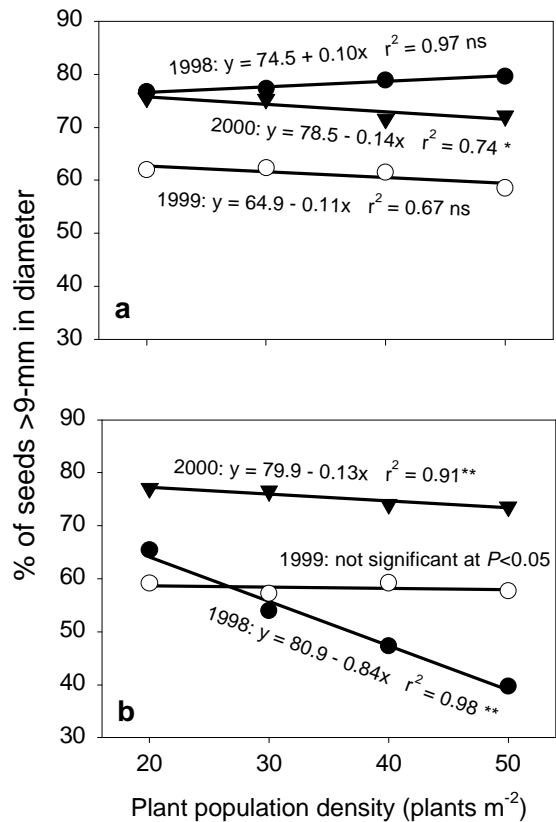


Fig. 2. Relationship between plant population density and the proportion of large-sized (>9-mm) seed for kabuli chickpea grown on a) conventional summerfallow, and b) on wheat stubble in southwestern Saskatchewan. (Equations with *,** are those whose slopes were significant at $P < 0.05$ and $P < 0.01$ from zero, respectively; ns means the slopes were not significant from zero).

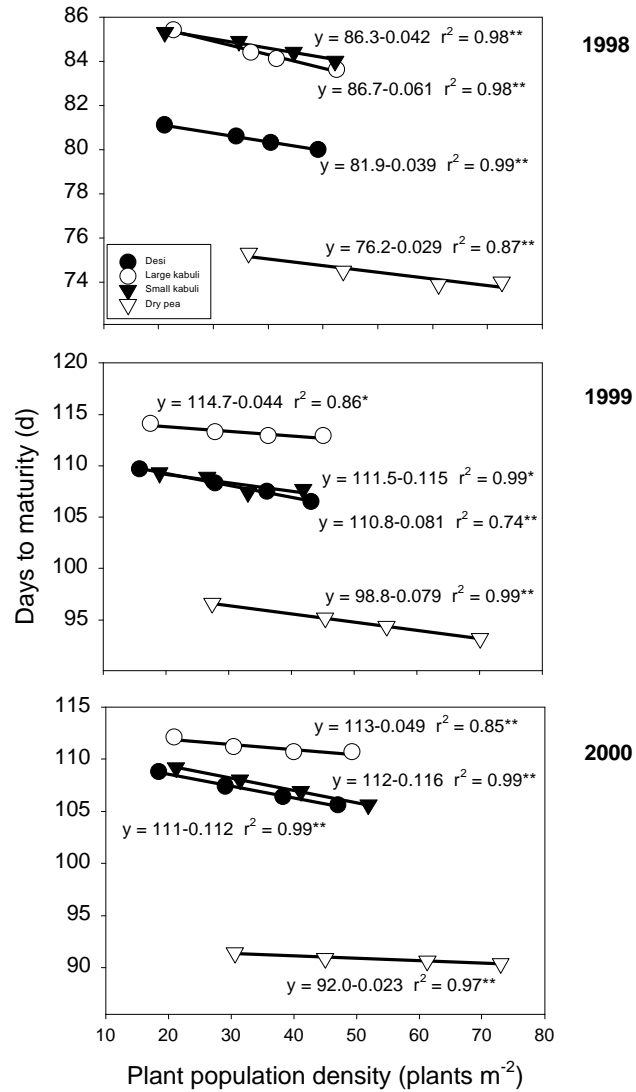


Fig. 3. Relationship between plant population density and days to maturity for three market classes of chickpea and dry pea grown in southwestern Saskatchewan, 1998-2000. (Equations with *,** are those whose slopes were significant at $P < 0.05$ and $P < 0.01$ from zero, respectively; ns means the slopes were not significant from zero).