# Chickpea Pod Infertility: A Potential of Improving Seed Yield

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## ABSTRACT

Chickpea (*Cicer arietinum* L.) is being rapidly adapted to the semiarid Canadian prairies, but little is known about morphological responses of this annual legume to growing conditions. This study, conducted in southwestern Saskatchewan, examined the morphological plasticity of three market classes of chickpea by growing the crop at four plant population densities. Chickpea grown at the high (50 plants $m^{-2}$) population density produced approximately half as many fertile pods per plant as those grown at the low (20 plants $m^{-2}$) density, but total number of pods per unit area increased with increasing plant population density. Large-seeded kabuli chickpea produced fewer pods per unit area, or <50% of that produced by small-seeded kabuli, and <60% of that by desi chickpea. Infertile pods accounted for 17 to 23% of the total pods for large-seeded kabuli, 9 to 12% for small-seeded kabuli, and 6% for desi chickpea. The pod infertility increased with increasing plant population density in both large- and small-seeded kabuli chickpea, but in desi chickpea it was consistently low across different population densities. The large-seeded kabuli produced <87 seeds for every 100 pods produced, whereas desi and small-seeded kabuli produced >110 seeds for every 100 pods. The yield potential of desi and small-seeded kabuli chickpea can be increased by increasing plant population density, whereas the seed yield of large-seeded kabuli can be improved by reducing the proportion of infertile pods.

## INTRODUCTION

The current emphasis on soil heath, environmental quality, and innovation for economic growth has stimulated significant changes in cropping systems in the semiarid Canadian prairies where there is an increasing interest in growing alternatives to cereal crops. In Saskatchewan, for example, the area seeded to chickpea has increased from less than 6,000 ha in 1995 to more than 400,000 ha in 2001; >90% of which is concentrated in the Brown and Dark Brown soil zones (Gan and Noble, 2000). Three market classes of chickpea (namely desi, large-seeded kabuli, and small-seeded kabuli) are currently grown in these regions. Large-seeded kabuli chickpea has an average kernel weight between 440 and 550 mg $kernel^{-1}$, and small-seeded kabuli has an average kernel weight of 200 to 300 mg $kernel^{-1}$. The seed coat of kabuli chickpea is thin with a creamy color. Relative to kabuli chickpea, desi chickpea has a seed size varying from 170 to 320 mg $kernel^{-1}$, depending on cultivars. The seed coat of desi chickpea is thicker and usually tan to dark brown colored. Chickpea is one of the highest valued crops in western Canada, with large-seeded kabuli chickpea priced at \$580 to \$800 $t^{-1}$ and desi chickpea \$350 to \$550 $t^{-1}$ in the last three (1999-2001) years, which was, respectively, 4.5 to 2.5 times the grain price of hard red spring wheat during the same period of time. Like other annual pulses, chickpea is a crop suitable for cereal-pulse rotation systems (Gan et al., 2001). Durum grown after chickpea increased the grain yield by 5 to 10% and increased grain protein concentration by 6 to 16% as compared to durum grown after wheat. Chickpea is a new crop in western Canada, and there is little information available regarding the morphological characteristics and its response to crop management. Knowledge on plant morphology is crucial in understanding the response of the crop to growing conditions and in developing corresponding agronomic strategies to manage the crop. Information on plant plasticity is also useful in screening varieties that will be better adapted to the semiarid environments. The objective of this study was to determine the morphological plasticity of three market classes of chickpea by determining pod development and seed formation as the crop was grown with different plant population densities.

## MATERIALS AND METHODS

This research project was conducted in 1999 and 2000 at the Agriculture and Agri-Food Canada Semiarid Prairie Agricultural Research Centre, Swift Current. The experiment was set up as a factorial, randomized complete block design with four replicates. Three market classes of chickpea, a) large-seeded kabuli (c.v. CDC Xena and CDC Yuma), b) small-seeded kabuli (c.v. CDC Chico and B-90), and c) desi (c.v. Myles), were planted directly into wheat stubble with four target population densities: 20, 30, 40, and 50 plants $m^{-2}$. The seed rates were determined according to seed size, germination, and an estimated field emergence rate of 70%. The precise seeding rates were accomplished by using a cone spreader built in a hoe press drill adapted for plot work. Each plot was 7.5 m long and consisted of 10 rows with 20-cm row spacing. Seed was placed at 5 to 6 cm deep, with phosphorous fertilizer applied 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 for symbiotic N fixation (Lipha Tech Inc., Saskatoon, Canada). Weeds were controlled using a combination of pre-planting or pre-emergent application of glyphosate and in-crop herbicide (*metribuzin*) applications. One to three applications of chlorothalonil were applied to control *Ascochyta*. At plant maturity, ten individual plants were sampled from each plot. All pods were opened by hand and the number of seeds in each pod was counted. We separately recorded the number of pods bearing 0, 1, and 2 seed(s), and calculated the total number of seeds per 100 pods. Data for the ten individual plants were averaged for each plot. The mean values were analyzed using the PROC MIXED procedure of SAS.

## RESULTS AND DISCUSSION

Actual plant population densities were close to the targets for all market classes in both years (data not presented). The four levels of population-density treatments created different crop communities that allowed us to determine the impact of plant population density on the morphological characteristics of all chickpea classes. Total number of fertile pods per plant decreased significantly as the plant population density increased from 20 to 50 plants $m^{-2}$ (Table 1); this pattern was similar for all three market classes. Plants grown at the high (50 plants $m^{-2}$) density produced approximately half as many fertile pods (per plant) as those grown at the low (20 plants $m^{-2}$) population density. The decreased pod production with increasing plant population density was presumably due to plant-to-plant competition for resources, as indicated from the Australian studies conducted by Beech and Leach (1989) and Jettner et al. (1999). Significant differences occurred in pod production among the chickpea market classes examined in the present study. Desi chickpea produced the highest number of fertile pods per plant, which was more than double the number of pods produced by large-seeded kabuli, and was 20% higher than those produced by small-seeded kabuli chickpea. Over 96% of the pods contained one seed in large-seeded kabuli, while the one-seeded pods accounted for 80% of the total pods for desi chickpea, and 75% for the small-seeded kabuli. The rest of the fertile pods contained two seeds. The small-seeded kabuli had the highest percentage (26%) of pods containing two seeds, followed by desi chickpea (19%). The large-seeded kabuli chickpea had <4% of the pods containing two seeds. The large-seeded kabuli chickpea apparently had limited sink size for accommodating more than one seed per pod.

The number of pods per unit area is the most important component contributing to final seed yields of pulse crops, including kabuli chickpea (Beech and Leach, 1989), desi chickpea (Jettner et al., 1999), faba bean (*Vicia faba* L.) (Marcellos and Constable, 1986), and lentil (*Lens culinaris* Medik.) (Siddique et al., 1998). In our study, pods per unit area increased significantly with increasing plant population density for all three market classes (Table 1). For example, desi chickpea increased fertile pods $m^{-2}$ by 28% as plant population density increased from 20 to 50 plants $m^{-2}$. Similarly, the fertile pods $m^{-2}$ increased by 10% for large-seeded kabuli, and by 25% for small-seeded kabuli chickpea, with the increasing plant population density. Chickpea market classes differed in the production of pods per unit area. The large-seeded kabuli produced the lowest number of pods per unit area, which was less than 60% of the pods produced by small-seeded kabuli, and less than 50% of the pods produced by desi chickpea. The differences in pod production among the market classes became more pronounced as the crop was grown at a high population density. For example, at 20 plants $m^{-2}$, large-seeded kabuli plots had 53% as many pods $m^{-2}$ as desi plots; while at 50 plants $m^{-2}$, the large-seeded kabuli plots had 46% as many pods $m^{-2}$ as desi plots. These results indicate that the large-seeded kabuli chickpea has lower plasticity or weaker buffering capacity than desi type, particularly when they are grown in an environment where plant-to-plant competition for resources is high.

There was a high percentage of pods producing no seed in chickpea (Table 1). Large-seeded kabuli had the highest percent pod infertility (17-23%), followed by the small-seeded kabuli (9-12%), with desi chickpea having the lowest (6%) percentage of infertile pods. With the increase of plant population density, the percent infertile pods increased significantly for the two kabuli market classes, whereas desi chickpea had a consistently low ratio between infertile and fertile pods. Due to the high percent of pod fertility failure, the large-seeded kabuli plants produced less than 87 seeds for every 100 pods produced. In contrast, desi plants produced 110 to 114 seeds and the small-seeded kabuli plants 110 to 117 seeds, for every 100 pods they produced. These results indicate that the seed yields of desi and small-seeded kabuli chickpea can be increased by increasing plant population density, whereas the yield potential of large-seeded kabuli chickpea can be increased by reducing the proportion of infertile pods. These goals of maximizing the seed yield of chickpea in the semiarid Canadian prairies can be achieved through the improvement of genetic manipulation, and use of optimal agronomic management practices.

## ACKNOWLEDGMENTS

We acknowledge the financial support provided by Saskatchewan Pulse Growers, the Agricultural

Development Fund of Saskatchewan Agriculture and Food, and the Matching Investment Initiative of Agriculture and Agri-Food Canada.

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**Fig 1.** Fertile pods per plant for three market classes of chickpea in Swift Current, 1999 and 2000.

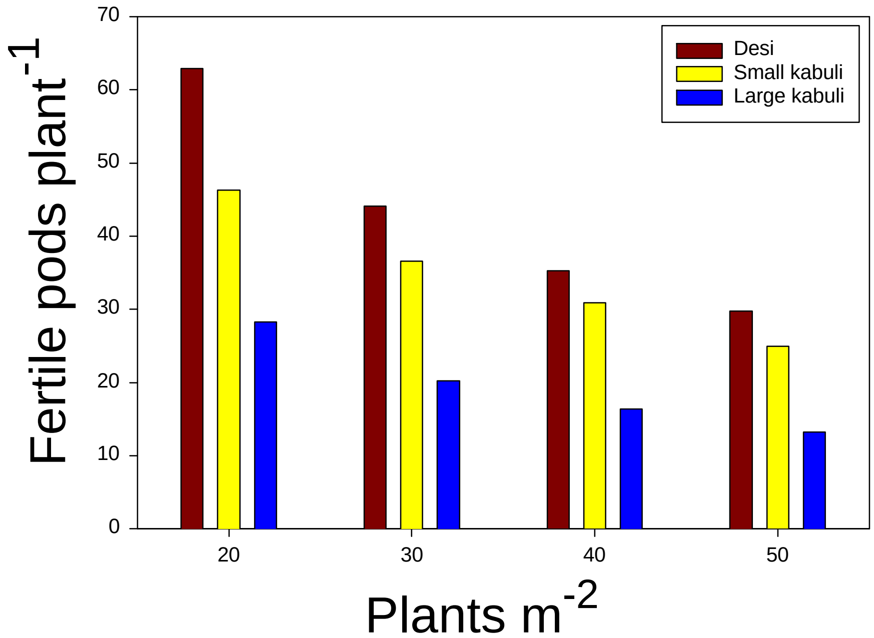


**Fig 2.** Number of fertile pods per unit area for three market classes of chickpea in Swift Current, 1999 and 2000.

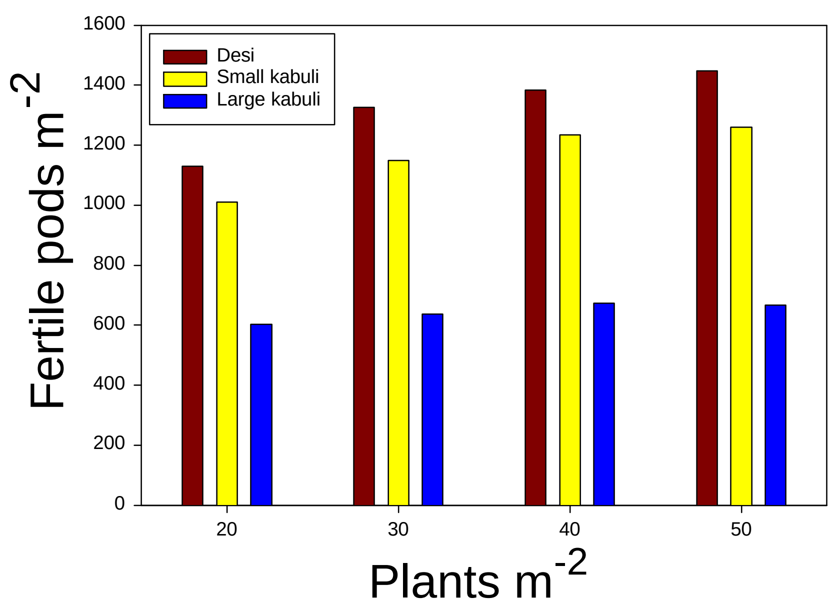

**Fig 3.** Prercentage of infertile pods per plant for three market classes of ckickpea in Swift Current, 1999 and 2000.

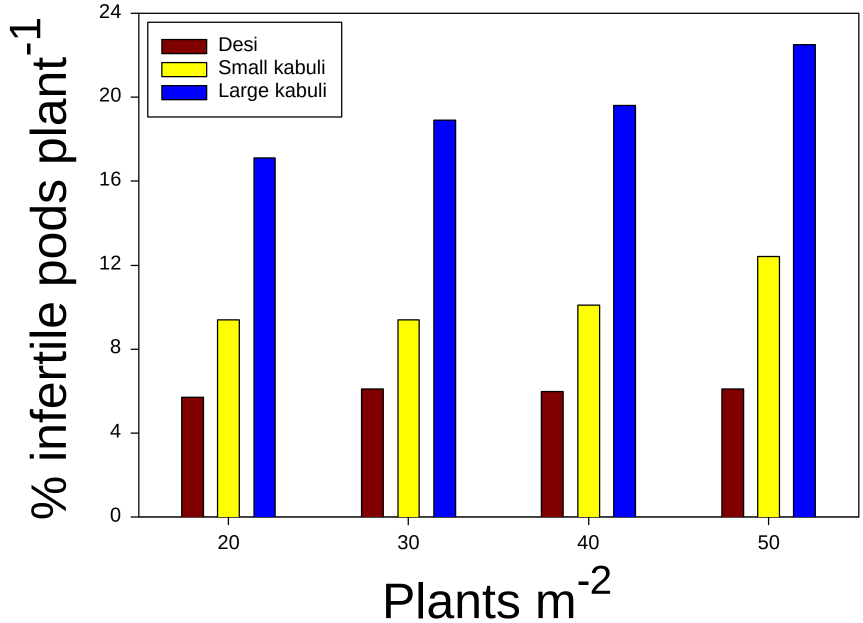


**Table 1.** Pods per plant for three market classes of chickpea in Swift Current, 1999 and 2000.

| Plants $m^{-2}$ | One-seed pods $plant^{-1}$ | | | Two-seed pods $plant^{-1}$ | | |
|---|---|---|---|---|---|---|
| | Desi | Small kabuli | Large kabuli | Desi | Small kabuli | Large kabuli |
| 20 | 50.9 | 32.7 | 27.1 | 12 | 13.6 | 1.2 |
| 30 | 34.8 | 27 | 19.5 | 9.3 | 9.6 | 0.8 |
| 40 | 28.5 | 23.5 | 15.9 | 6.8 | 7.4 | 0.5 |
| 50 | 24.2 | 19.6 | 12.8 | 5.5 | 6.1 | 0.4 |
| P<0.05 | <0.01 | <0.01 | <0.01 | 0.03 | 0.08 | 0.12 |