Yield Adjustment by Canola Under Different Plant Populations in the Semiarid Prairie

S. Angadi, H. Cutforth and B. McConkey

Semiarid Prairie Agricultural Research Centre, Swift Current

Introduction

Crop production is the efficient conversion of resources like light, water, nutrients, growing space into seed yield. Plant population is a management tool used to optimize use of all resources to achieve maximum yield. In semiarid regions water is the most limiting factor. Therefore, avoiding haying off is also important.

Little is known about canola response to plant density in the semiarid prairie, where establishing a good standing crop is important to successful crop production. Seed size, sowing mechanisms and abiotic factors like low temperature, water stress and soil crusting contribute to poor crop stand. The space available for growth represent the availability of resources like light, water, nutrients, and physical growing space for growth for individual plants. Optimum population density depends on the environment, with higher yield potential environments having higher population optimum than lower yield potential environments.

In earlier studies on plant population, weed competition was a major factor limiting resource use efficiency at lower plant populations. Therefore, to increase competition higher plant populations were adopted. Similarly, for the same reason seeding was recommended after killing spring weeds. However, compared to the traditional spring seeding dates, the benefits of early spring or late fall seeding are often substantial and with the availability of herbicide tolerant canola, weeds are easily removed from canola fields. Therefore, a rethinking about optimum plant population is needed.

Past literature has frequently affirmed the importance of a uniform plant stand for increasing yield. But, often non-uniform spacing is a rule of nature. Variations in soil physical conditions, soil moisture, temperature, and seeding equipment results in nonuniform plant stands. There is very little information available on the effect of nonuniform plant population on canola yield. Therefore, the objectives of this investigations were to determine (1) how canola maintains seed yield over a range of population density, (2) how plant population affects yield component distribution on the plant, and (3) identify the threshold population when re-seeding should be considered.

Materials and Methods

Studies were conducted at the Semiarid Prairie Agricultural Research Centre, Swift Current during 1999 and 2000. The soil type was Swinton silt loam. Argentine canola (cv. Arrow) was seeded on 6th May 1999 and 25th April 2000 with an air drill on 23 cm row widths. A higher seeding rate of 12 kg ha^{-1} was used to get a good and uniform population density. At the 2 to 4 leaf stage seedlings were thinned to uniform plant stands of 80, 40, 20, 10, and 5 plants m^{-2}. To obtain non-uniform plant stands, seedlings from alternate 1m length from two adjoining rows were removed and when two adjacent rows had the seedlings removed, the next two rows had seedlings retained and vice versa. Thus, by removing half of the plant population from 80, 40 and 20 plants m^{-2} plots, we obtained 40, 20, and 10 plants m^{-2} non-uniform population plots. Plot sizes ranged from 14.6 m^2 (1999) to 22.5 m^2 (2000). In spring, fertilizer mixture providing 84 kg N, 24 kg P and 22 kg S ha^{-1} was broadcasted.

At harvest, 2 m to 6 m length of row were hand harvested to assess biomass yield and harvest index. An area of 4 m^2 to 7 m^2 was combined with a plot combine to assess seed yield. Observations on number of fertile branches, number of pods per plant, seeds per pod (from randomly selected pods from terminal spikelet) and thousand seed weights were made. In 2000, three plants each from all uniformly spaced treatment plots were harvested before combining to determine the contribution of different node numbers in forming fertile primary and secondary branches, and pod formation.

The experimental design for all trials was a randomized complete block design with 3 (2000) and 4 (1999) replicates. Wherever more than one sample was taken from each plot, the mean of the observations was used for analysis. Data was averaged over two years and significant effect of population was determined using analysis of variance technique. Relationship between uniform plant population levels and number of fertile branches, number of fertile pods and seed yield was assessed with regression analysis.

Results and Discussion

All observations are means of two years, unless specifically mentioned.

Number of Branches

The number of fertile branches (primary) increased with lower plant population (Fig. 1 and 2), i.e., a primary response of canola to lower plant population is increased branching. A strong quadratic relationship (r^2=0.99) between plant population and number of fertile branches was observed (Fig. 3, top left). However, the increase in primary branches did not compensate completely for the decreasing population. For example, a population of 80 plants m^{-2}, which was 16 times higher than 5 plants m^{-2}, had about half the number of branches compared to 5 plants m^{-2}. The effect of non-uniform plant stand on fertile branches was more evident at lower population densities.

Number of Pods

The number of pods on the main stem nodes in 2000 (top to bottom) showed a strong effect of population density on the distribution of pods on primary and secondary branches (Fig. 2). At the higher population (80 plants m^{-2}), canola produced pods of the primary branches on upper few nodes and the number of pods decreased more or less linearly with increase in node number. At the lower population (5 plants m^{-2}), peak pod production was observed a few nodes lower in the canopy with higher pod numbers observed on the 8th node before significant decrease in pod production was observed. In addition, a dramatic increase in the secondary pods was observed at the lower population. Peak secondary pod production was lower (5th node) in the canopy. At higher plant populations a greater fraction of pods were formed on the upper canopy and as plant population were reduced, more pods were formed lower on the plant.

The mean total number of pods during 1999 and 2000, increased with decreasing plant population (Fig. 3, top right). A strong quadratic relationship between uniform plant population levels and total pod numbers was observed (r^2=0.97). However, increased pod number did not compensate for decreased population completely. Non-uniform plant stands produced pod numbers similar to those produced by uniform plant stand except at 10 plants ha^{-1}, at which the non-uniform plant stand reduced the pods per plant.

Biomass Production

The lower biomass produced at lower plant population was not statistically different from higher plant population (Fig. 3, middle left). Similarly, non-uniform plant stand had no effect on biomass. Thus, the plasticity of the canola plant maintained biomass production over a wide range of uniform as well as non-uniform population densities.

Harvest Index

The harvest index was independent of plant density, whether uniform or non-uniform (Fig. 3, Middle right).

Seed Yield

Seed yield reduced curvilinearly with reductions in plant population (Fig. 3, bottom left). Because of the plasticity of the canola plant, yields were maintained over a wide range of populations before yields began to decline. Thus, 80 or 40 plants ha^{-1} produced similar yields. A strong quadratic relationship between uniform population levels and seed yield was observed (r^2=0.94). In general, non-uniform densities produced seed yields similar to those for uniform densities except at 10 plants ha^{-1}, where the non-uniform stand significantly out yielded the uniform plant stand. Under the semiarid conditions, a lower plant population of 20 plants ha^{-1} of canola can produce seed yields only slightly lower (11% lower) than that of 80 plant ha^{-1}. Non-uniform plant stand generally did not result in a yield penalty.

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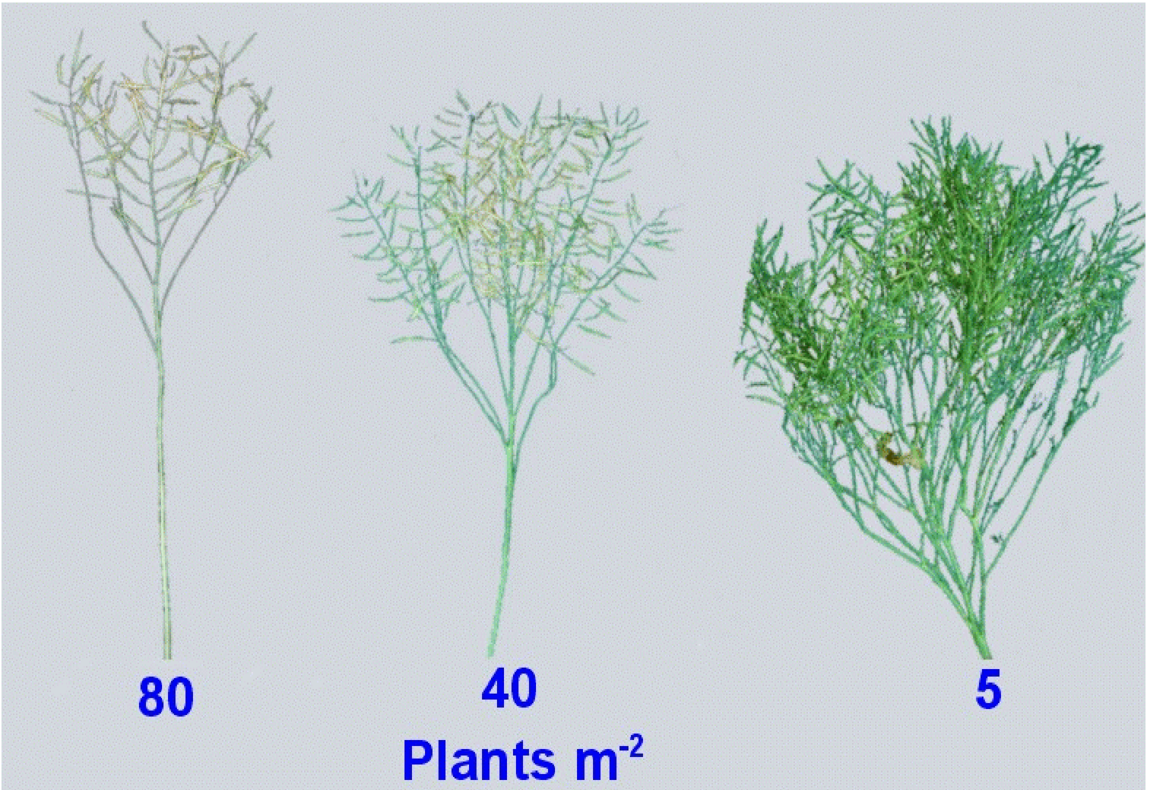

Fig. 1. Effect of different plant populations (uniform) on the branch and pod formation in canola 2000.

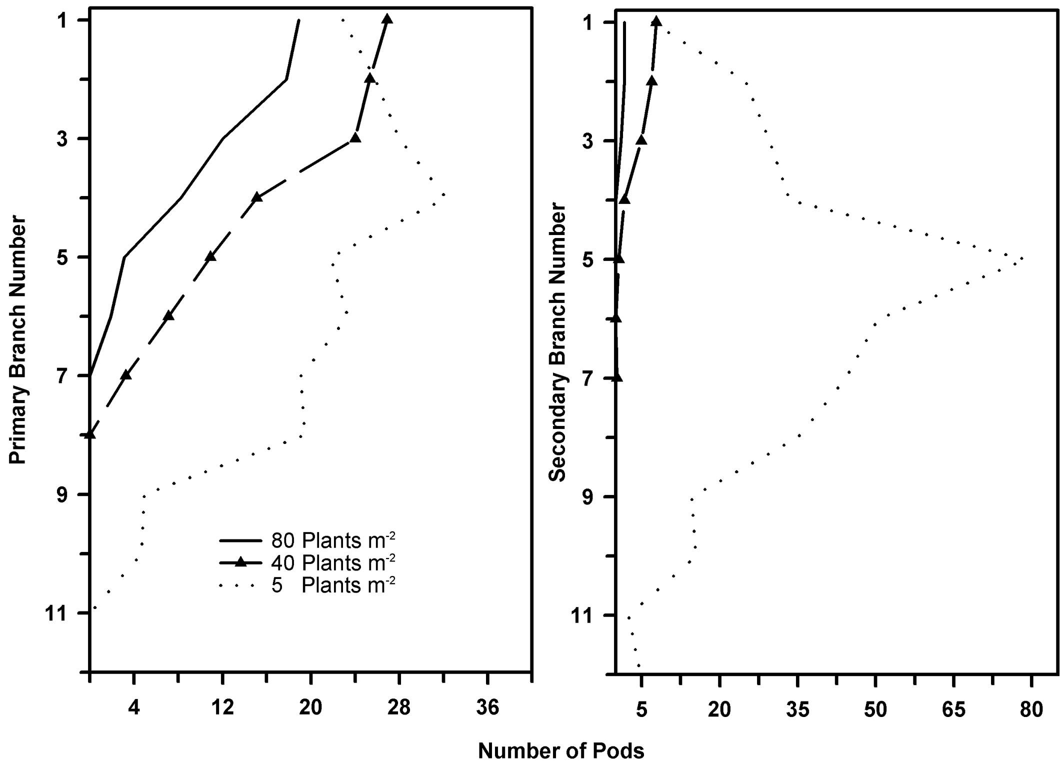

Fig. 2. Effect of population densities on pod formation on primary and secondary branches in canola in 2000.

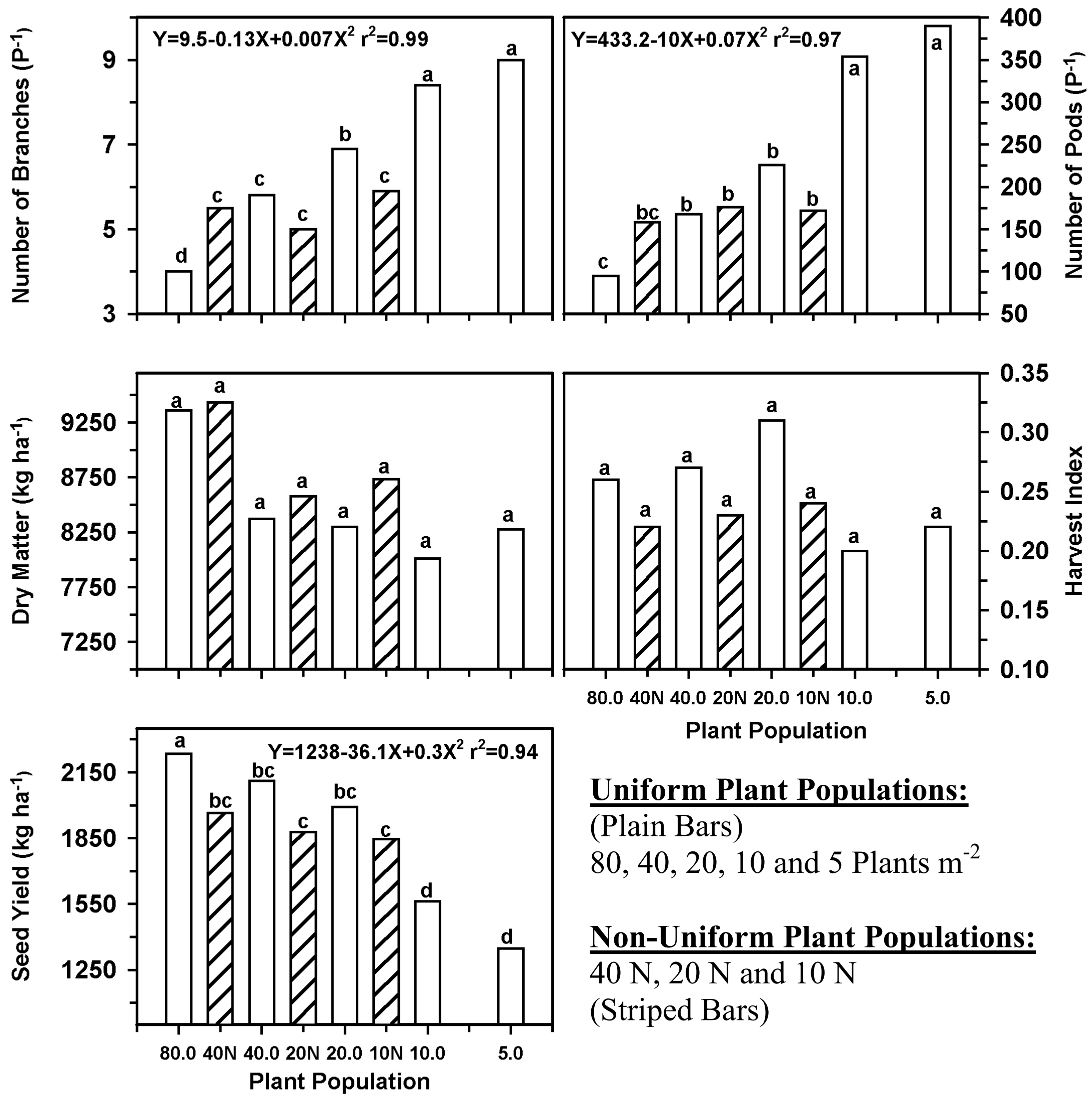

Fig. 3. Effect of uniform and non-uniform plant population densities on the number of fertile branches, number of total pods, total biomass, harvest index and seed yield of canola during 1999 and 2000 at Swift Current. Vertical bars with same letters were not significantly different. Relationships between uniform plant populations and respective parameter are presented when significant relationships were observed.