Canola Yield Formation Under Different Population and Water Use Levels

S. Angadi, H. Cutforth, B. McConkey and Y. Gan

Semiarid Prairie Agricultural Research Centre, Swift Current, SK S9H 3X2

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Abstract

Optimum population is the foundation for high yields under rainfed agriculture and the optimum population depends on the water availability. However, establishing a good canola stand in the Canadian semiarid Prairie, where low temperature, water stress and soil crusting result in poor seed bed conditions, is difficult. A field study was conducted during 2000, a year with moderate soil moisture and good canola growing conditions, and 2001, a year with severe water and heat stress, to understand the plasticity of canola yield parameters at different (80 to 5 plants per square meter) plant populations. The primary response of canola to lower plant population was increased branching, although it did not compensate completely for the decreasing population. Increased branching was accompanied by increased production and increased distribution of pods on the primary and secondary branches. Canola exhibited plasticity in yield adjustment over a wide range of plant populations. Environmental conditions played a significant role in expressing canola plasticity. For example, in a normal year like 2000 canola maintained similar yield levels over a wider range of populations (80 to 20 pl m^{-2}), while in a dry year like 2001 seed yield started declining with populations below 40 pl m^{-2}. Ability to produce more pods, especially at lower population densities, was responsible for the environmental influence on yield formation.

Introduction

Little is known about canola yield plasticity in the semiarid prairie, where establishing a good plant stand is important to successful crop production. Optimum population density depends on the environment. For example, in higher yield potential environments such as southern Manitoba, maximum seed yields were realized at relatively lower populations compared to populations recommended for canola on the prairies as a whole.

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 traditional spring seeding dates, the benefits of early spring or late fall seeding are often substantial. Therefore, with the availability of herbicide tolerant canola to control weed problems, a rethinking about optimum plant stand is needed.

Therefore, the objectives were to 1) to determine how canola maintains seed yield over a range of population densities under two contrasting environments, 2) to identify the relative importance of different yield components in canola yield plasticity under diverse environments and 3) to identify the threshold population when re-seeding should be considered.

Materials and Methods

A field study was conducted during 2000 and 2001 at the Semiarid Prairie Agricultural Research Centre, Swift Current, SK, Canada (50°17´ N 107°48´W) located in the Brown and Dark Brown soil climatic zones, a semiarid region generally considered marginal for canola production. The soil type was Swinton silt loam. Glyphosate tolerant Argentine canola cv. ‘Arrow’ was seeded under rainfed conditions on 25 April 2000 and 24 April 2001 using an air drill with 23 cm row widths.

All trials were conducted on fallowed fields and the crop previous to fallow was wheat. Vitavax RS (carbathiin + thiram + lindane) seed treatment was used to control seedling fungal diseases and provide protection against flea beetles. A higher seeding rate of 12 kg ha^{-1} was used to get a good, uniform population density. In spring, a fertilizer mixture of 84-24-0-22 kg N, P_2O_5, K and S ha^{-1} was uniformly broadcast over the experimental area. Post-emergent Glyphosate application was used to control weeds.

At the 2 to 4 true leaf stage, seedlings were hand thinned to uniform plant stands of 80, 40, 20, 10, and 5 plants m^{-2}. Thinning ensured maximum distance between plants in adjacent rows and uniform distribution of population in uniform plant stand treatments. Plot sizes ranged from 11.06 m^2 (2001ES) to 26.00 m^2 (2001LS).

Pods per plant were counted on three randomly selected plants. For detailed analysis of yield adjustment, three plants from the uniform population plots in 2000 and 2001 were harvested just before swathing. The number of pods produced on the terminal (main) raceme, on individual primary branches and on all other higher order branches at each node were counted. Fertile pods were defined as pods which contained at least one seed. The nodes were counted based on when they initiated flowering branches i.e. top downwards in canola. Pods from main raceme and each primary branch were counted and oven dried separately, while the pods from secondary and higher order branches were pooled for drying. The dry weight of pods, seed weight, and seed number from each main raceme and primary branches were used to calculate seeds per pod, thousand kernel weight and seed to pod ratio on each of those branches separately.

The experimental design for all trials was a randomized complete block design. Weather conditions varied significantly during the experimentation. Therefore, to understand canola response under favorable and unfavorable growing conditions, all grain yield and yield forming traits from each environment were analyzed separately. To understand the plant population effect under different seed yield potential, grain yield from each environment from each population were normalized to the grain yield at 80 plants m^{-2} and regressed against plant population.

Results and Discussion

Seasonal Conditions

- The rainfall in 2000 was favourable for canola production with more than double (2.4 times) of normal rainfall in July.
- Year 2001 was 2nd driest and 5th warmest year since 1883. Overall May-August rainfall in 2001 was less than 50% of 2000 and 57% of long-term normals.

Growth Response to Population

- As the population density decreased the leaf area index (LAI) decreased (Fig. 1). However, the gap narrowed at the later stages because plants at lower population densities continued to increase LAI through extra branching and pod formation (longer growth duration), while those at higher populations started senescing.

Yield Components

- Number of pods per plant was the most responsive yield parameter (Fig. 2).
- At higher population densities most pods were on the primary branches and were near the top of the canopy. As population decreased, the contribution from lower nodes and secondary branches increased (Fig. 2).
- Environment had a significant effect on pod number compensation: In 2000 reducing plants from 80 to 40 plants m^{-2} increased pod number by 74%, while under the higher stress conditions of 2001, compensation was only 28% (Fig. 3).
- Canola used secondary branches to produce extra pods only under good growing conditions (Fig. 2).
- Increased pod number partially compensated for decreased population.
- Seeds per pod and seed weight had no role in yield compensation in the upper part of canopy, although a population effect was observed at the lower nodes (Fig. 2).

Seed Yield

- Sub optimal plant population and stressful environment reduced canola yield (Fig. 4).
- Due to the plasticity of canola, seed yields for 80 and 40 plants m^{-2} were similar.
- Under good growing conditions, a population as low as 20 plants m^{-2} had no yield penalty compared to 80 plants m^{-2} , however, under poor growing conditions the yield penalty was 35%.
- Normalized seed yield clearly indicated the role of growing environment on canola yield plasticity (Fig. 5).

Summary

Canola plasticity depended on growing environment. Under good growing conditions (2000) canola adjusted yield over a wide range of population densities, while under stressful environment (2001) canola was more responsive to population variations. Number of pods per plant was mainly responsible for the yield adjustment by canola. A population of 20 m^{-2} would be a reasonable threshold for reseeding canola in the semiarid prairie.

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