Exploring the Yield Potential of Spring Canola: Border Effects in a Controlled Environment Study

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Abstract

Investigating the upper limits of crop yield potential in controlled environment experiments requires accurate simulation of the canopy light environment by accounting for border effects. We conducted a greenhouse experiment to determine the width of unharvested border required to measure true yield potential in hybrid spring canola. Plants were grown five per pot, with 64 24-cm pots arranged in an 8 x 8 grid (plant density = 87 m^{-2}). The seed yield in the absence of border effects was 6.2 Mg ha^{-1}, or about twice a typical field yield. Pots on the outer edge of the grid yielded 40% higher than this; the increase was attributable entirely to increased seed yield on branch racemes, as main racemes were unaffected. The increased yield on branches was due to the increased branch number and associated increased pod number, not seeds per pod or seed size. A buffer 0.48 m (two pots) wide was sufficient to fully eliminate border effects.

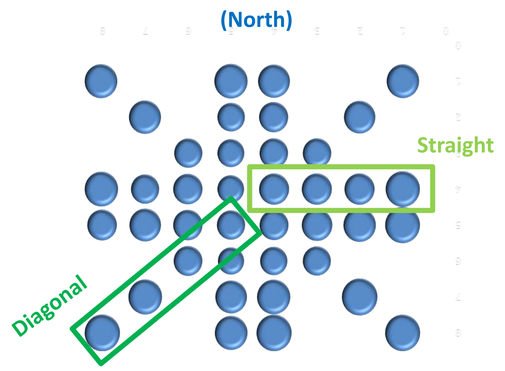
Hypothesis and Predictions

In greenhouse experiments plants are generally grown in pots at densities that differ from normal plant populations in a field environment. The lack of normal interplant competition strongly affects single plant morphology. Estimating yield on a ground area basis from single pots requires that those plants are grown in a realistic light environment with normal interplant light competition. In canola a lack of light competition strongly increases branching and pod numbers, thus increasing single plant yield. It should be possible to eliminate such overestimation of yield by surrounding measured plants with a sufficient number of unharvested border plants. We predicted that yield of greenhouse-grown canola plants would decline as the number of border pots was increased, but eventually would reach a stable value, representing the true yield in the absence of edge effects.

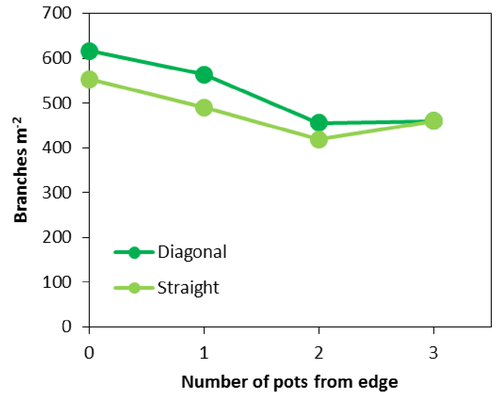
Approach

The spring canola hybrid variety InVigor 5440 was grown in a greenhouse at 5 plants per pot in 64 24-cm diameter pots, arranged in an 8 x 8 grid. Final plant population was 87 m^{-2}. At physiological maturity plant number per pot and branches per plant were counted, and pod numbers, seed numbers, seed yield and 1000-seed weight were determined for main racemes and branch racemes separately.

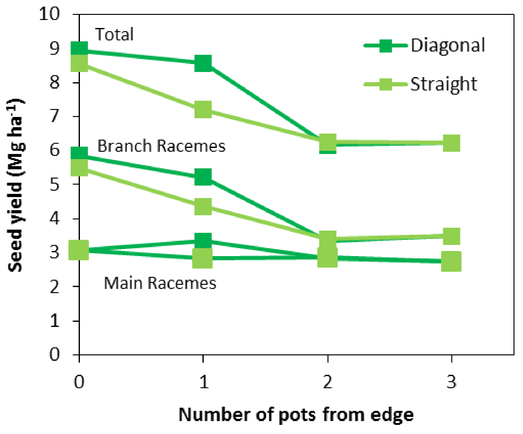
Results

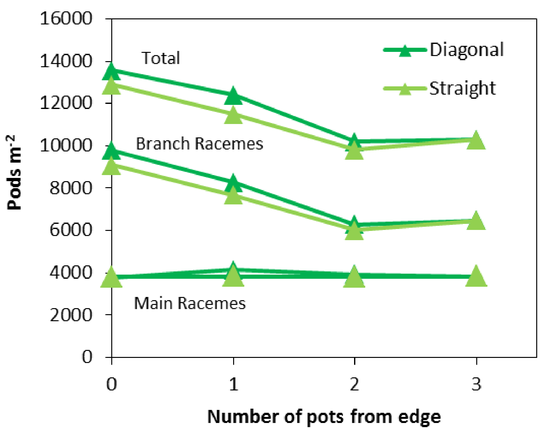


Bubble chart showing relative seed yield for 40 pots, by pot position within an 8 x 8 pot grid. Seed yield is proportional to the area of each bubble.



Number of branches decreased significantly ($p < 0.001$) from the edge of the experiment to the center. Two border pots were sufficient to maximize this effect.





Seed yield per unit ground area decreased significantly ($p < 0.0001$) from the edge of the experiment to the center (left). Two border pots were sufficient to maximize this effect. The change in seed yield with pot position was due entirely to differences in seed yield on branch racemes; yield of main racemes was not affected ($p = 0.47$). The yield component affected by pot position was the number of pods borne on branch racemes (right). There was no effect on main raceme pod numbers. Other yield components (seeds per pod and 1000-seed weight, both on branches and main racemes) were also unaffected by pot position (data not shown).

Conclusions

1. A border of two pots (48 cm) was sufficient to eliminate edge effects in this experiment. Yield estimates from plants inside the two-pot border were not inflated by artificially low interplant competition for light.
2. In the absence of edge effects, yields were much higher (about twice) typical field yields at 6.2 Mg / ha. It is not known if the cultural system employed here was yield-maximizing; maximum genetic yield potential of this variety may be higher still.
3. The response of yield to reduced interplant light competition was entirely attributable to a single yield component: number of pods borne on branch racemes.