Impact of Seeding Rate on Weed-Free Field Peas

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Abstract

The impact of seed placement and seeding rate on crop yield is not clearly understood for field pea (*Pisum sativum* L.). A field experiment was conducted at seven sites across Saskatchewan in 2001 to examine the influence of a wide range of seeding rates (20, 30, 40, 50, 60, 70, 80, 90, 100, and 120 target plants m^{-2}). Yield component compensation occurred where increased plant density from higher seeding rates reduced seed weight. Seed yield benefits were small at seeding rates greater than 50 target plants m^{-2}. There was a tendency for lower yields with seeding rates less than 50, especially at sites with higher yield potential. Yields of field peas grown under relatively weed-free conditions should be optimized with a seeding rate of 50 to 75 seeds m^{-2}.

Introduction

Field pea plays an important role in crop rotations on the Canadian prairies. Current popularity in pulses has resulted in a heightened interest to determine management practices that ensure maximum pea yields with low production costs. Manipulation of plant populations, through varied seeding rates and seed placement, is a critical management input that can be used to modify crop productivity.

Materials and Methods

An experiment was conducted at seven sites across Saskatchewan in 2001 to examine the effect of seeding rate on pea production. General information for each site is summarized in Table 1. Ten seeding rates (20, 30, 40, 50, 60, 70, 80, 90, 100 and 120 targeted plants m^{-2}) were arranged in a randomized complete block design with four replicates. A semi-leafless upright cultivar (cv. Swing) was used at all trial locations. The target seeding rates were calculated using seed weight and germination rate, discounted by 5% to account for seedling mortality. A combination of fall preemergence applications of ethafluralin, preseeding applications of glyphosate, and/or in-crop applications of imazamox + imazethapyr were used to control weeds.

Pea seedlings were counted 3-4 weeks after seeding in two to four 1-m sections of crop row. Seed samples were harvested with a plot combine, dried to constant moisture, cleaned and weighed. Seed weight was established from a sample of 1000 seeds. Data from each experiment were analyzed separately with the PROC MIXED procedure of SAS (Littel et al. 1996) with block as a random effect, and site and seeding rate as fixed effects. Treatment effects were declared significant at $P < 0.05$ for all analyses. Seed yield was regressed against seeding rate using an inverse polynomial model with a modification for yield depression at high seeding rate (France and Thornley 1984):

$$\mathrm{Y} = u \times \mathrm{SR}\ \left(\left(1 - \mathrm{SR}\right)/s\right)/\left(SR + \left(u/e\right)\right) \qquad \text{(Eq. 1)}$$

where Y = predicted grain yield (kg ha^{-1}), SR = seeding rate (target plants m^{-2}), u = upper limit of yield (kg ha^{-1}), e = slope, or the maximum response to seeding rate at the lesser seeding rates (kg yield per 1 plant m^{-2} change of the target seeding rate), and s = yield depression, or the sensitivity at the highest seeding rates (larger s values indicate less sensitivity). Least squares estimates of the coefficients were obtained with the PROC NLIN procedure in SAS (SAS Institute 1996). SR_{max}, the seeding rate at which maximum yield occurred, was estimated by differentiating Eq. 1 with respect to seeding rate, and setting the result equal to zero:

$$\mathrm{SR}_{\mathrm{max}} = u/e\ \left(\left(1 + \left(e \times s/u\right)\right)^{1/2} - 1\right) \qquad \text{(Eq. 2)}$$

Substitution of SR_{max} into Eq. 1 provided an estimate of maximum yield.

Results and Discussion

The proportion of seedlings that emerged relative to the corresponding target seeding rate decreased from 116 to 103 percent when seeding rate was increased from 20 plants m^{-2} to 30 plants m^{-2}, and then decreased to an average of 89 percent for the remaining seeding rates greater than 30 plants m^{-2} (Table 2; Fig. 1). The seeding rate effect on seedling density was similar at individual sites (results not shown), although responses at individual sites were not statistically similar. Seed weight declined in response to greater plant density at all sites, except at the high yielding Outlook site (results not shown) where seed weight decreased slightly with each increase in target seeding rate (Fig. 2). The absence of a site by seeding rate interaction indicates that seeding rate affected pea seed yield similarly at all sites (Table 2). The estimated optimum seeding rate for seed yield was 108 (range of 82–112 among individual sites) targeted plants m^{-2}, although yield increases were small at target seeding rates greater than 50 plants m^{-2} (Table 3). The economic returns from seed rates above 50 plants m^{-2} may not warrant the extra seed cost. Seed yield was reduced over all sites with seeding rates less than 50 plants m^{-2}, particularly at the high yielding Outlook site and lesser so at the low yielding Swift Current site. This tendency was reflected by the greater '*e*' regression coefficient for Outlook compared with Swift Current.

Seedling mortality increased with seeding rates above 50 seeds m^{-2}. Greater inter-plant competition, as plant density increased, would explain the corresponding increase in seedling mortality and associated stand loss (Puckridge and Donald 1967). However, increased seedling mortality and reduced seed weight with progressively greater seeding rates was not reflected in lower seed yield. While not carried out in this study, measurements of seeds per pod might have contributed to a more comprehensive understanding of yield component compensation and associated yield responses to seeding rate, across the range of growing conditions sampled (Ney et al. 1994).

Plant populations of 50 seedlings m^{-2} and above should provide a sufficient density to deal with the environmental variation experienced on the Canadian prairies. Under the wide range of growing conditions experienced in 2001 (from July terminal drought to irrigated), similar yield responses to seeding rates beyond 50 targeted plants m^{-2} occurred. Seeding rates below that required to achieve 50 plants m^{-2} should be avoided, especially at those sites where water availability is not limited. Tompkins et al. (1991) also observed similar trends for winter wheat, with the influence of reduced seeding rates on grain yield most notable in high-yielding environments. Therefore, seedling stands below 50-60 plants m^{-2} should be avoided with upright semi-leafless field pea cultivars in sub-humid and irrigated regions.

Future research should focus on the agronomic and economic effects of seeding rate as an integrated pest management practice. Field pea growers will have to adjust their seeding rate in an attempt to balance the impact of environmental conditions on seedling emergence, so as to obtain plant stands of at least 50 – 60 plants m^{-2}.

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Table 1. General information for 2001 experiment conducted at sites located across SK, Canada.

Attribute	S.Current	Scott	I.Head	Redvers	Canora	Melfort	Outlook
Soil texture	CL	L	HvyC	CL	CL	SiC	FSL
pH	7.6	6.0	7.5	7.4	8	6.4	7.4
OM	1.7	3–4	3.5	4.5–5.5	7.5–8.4	11	2.2
Previous crop	Durum	Fallow	Barley	Barley	Barley	HRS wheat	Potato
Tillage system[z]	Minimum	Conventional	Direct	Minimum	Direct	Direct	Direct
Plot size (m)	4.6 x 18.3	2 x 5	4.0 x 10.7	3.4 x 9.1	3.7 x 8.5	4.0 x 7.3	1.5 x 7.3
Row space (cm)	22.9	21	30.5	26.7	26.7	30.5	25.4
Fertilizer rates (N-P kg ha^{-1}) / placement[y]	3-5 / side band	5-10 / seed row	5-9 / side band	11-24 / side band	6-10 / side band	2-4 / side band	11-20 / side band
Granular inoculant (kg ha^{-1})	6.0	5.6	5.6	6.0	6	5.6	10.0
Growing conditions	Warm / dry	Warm / normal then dry	Warm / dry	Warm / above normal	Warm / above normal	Warm / dry	Warm / irrigated

[z] Number of primary/secondary tillage passes: Conventional = 2 or more, Minimum = 1, and Direct = none.
[y] Applied as monoammonium phosphate.

Table 2. Pea responses to seeding rate at seven sites located across SK, Canada, in 2001.

	Seedling density			
	Actual	Proportion[z]	Seed yield	Seed weight
Analysis of variance		(*P* value)		
Seeding rate (R)	< 0.001	< 0.001	< 0.001	0.005
Site (S)	< 0.001	< 0.001	< 0.001	< 0.001
S x R	< 0.001	< 0.001	0.512	0.002
CV		(%)		
All sites	53	39	65	5

[z] Proportion of seedlings emerged relative to the corresponding seeding rate.

Table 3. Regression coefficients for pea seed yield responses to seeding rate at sites located across SK, Canada, in 2001.			
Site	e^z	SR_{max}	$Yield_{max}$
Swift Current	160	112	1478
Scott	77	104	1510
Indian Head	86	87	1353
Redvers	387	90	3410
Melfort	588	103	2583
Outlook	675	82	6143
All sites	320	108	2757

[z] A non-linear inverse polynomial model was used to estimate the following regression coefficients: *e* = slope; maximum response to seeding rate at lowest seeding rates (kg yield per 1 plant m^{-2} of target seeding rate). SR_{max}, the seeding rate at which maximum yield occurred, and $Yield_{max}$, maximum yield (kg ha^{-1}), were calculated using derivations of the preceding model.

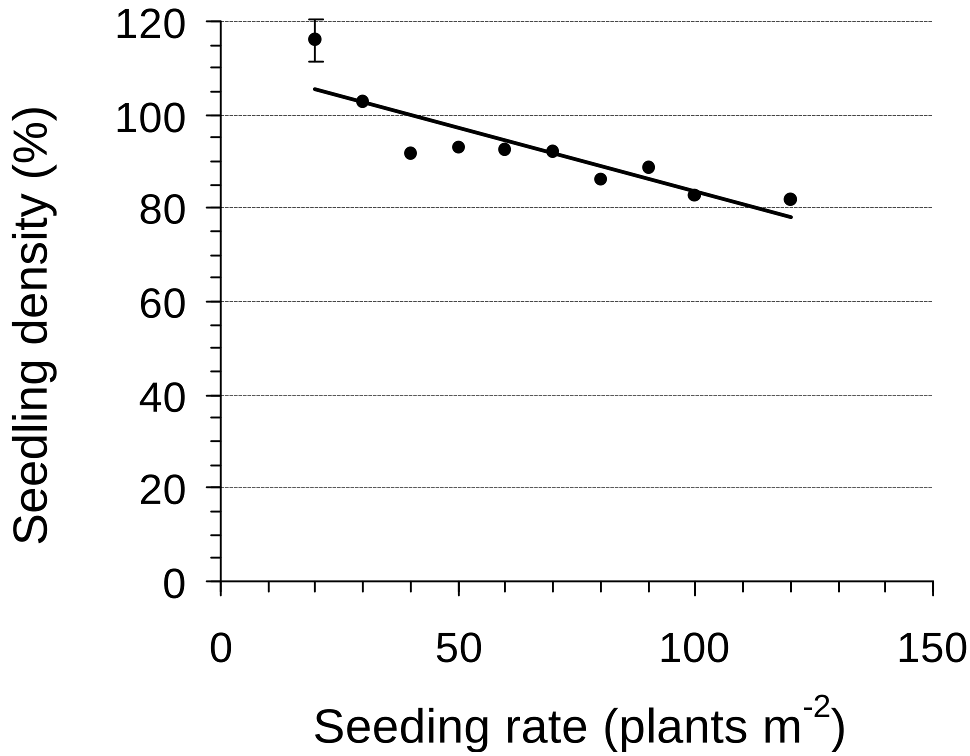

Figure 1. Field pea seedling emergence responses to seeding rate averaged across seven sites in Saskatchewan, Canada, in 2001. The error bars represent the $LSD_{0.05}$ for the main effect of seeding rate**.**

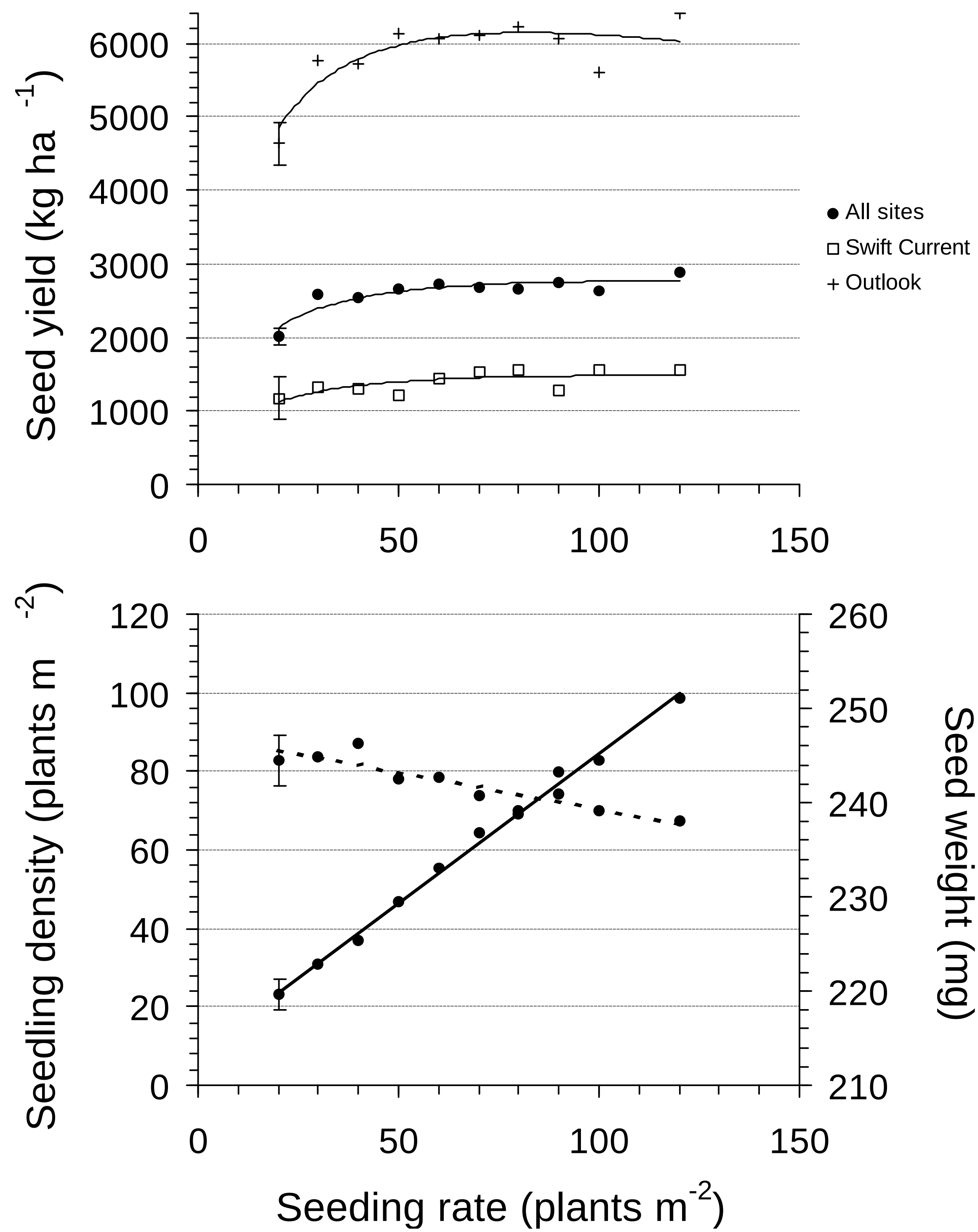

Figure 2. Field pea responses to seeding rate averaged across seven sites in Saskatchewan, Canada, in 2001. a) Average seed yield response and the two sites that exhibited the most extreme responses to seeding rate (Outlook and Swift Current). b) Seedling density (solid line) and seed weight (dashed line) in response to seeding rate. The error bars represent the $LSD_{0.05}$ for the main effect of seeding rate. An inverse polynomial regression model was fit to the seed yield data. Regression coefficients are summarized in Table 4.