Are Two Cultivars Better than One? Performance of Leafed and Semi-leafless Pea Mixtures under Weedy Conditions

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Abstract

There is a need for improved tools to minimize yield losses due to weeds for organic field pea production. Cultivar mixtures may improve the ability of organic pulse crops to suppress weeds and maintain yields in the presence of weeds. While semi-leafless peas are known for their lodging resistance and high yield potential in the absence of weeds, leafed (wild-type) peas may provide better weed suppression and yield stability in the presence of weeds. A replicated field experiment was conducted on organic land over five site-years to test the hypothesis that mixtures of leafed and semi-leafless field pea cultivars would improve weed suppression and yields relative to monocultures of the same cultivars. The experiment tested factorial combinations of five ratios of semi-leafless (cv. CDC Patrick or CDC Dakota), and leafed pea (cv. CDC Sonata) (0:100, 25:75, 50:50, 75:25, and 100:0, respectively), and two target seeding rates (88 and 132 plants m^{-2}). Plots were monitored for crop and weed emergence, biomass, and yields. Mixtures differed from their component monocultures in both weed control and yields. Levels of weed control in mixtures were intermediate to the component cultivars, and no weed control benefits were seen. While CDC Patrick mixtures did not out-yield CDC Patrick monocultures, mixtures of 75% CDC Dakota and 25% CDC Sonata out-yielded both respective monocultures by 12-196%. Results indicate that mixtures of leafed and semi-leafless cultivars may be used to improve organic pea yields in the presence of weeds. However, specific combinations of cultivars and mixing ratios should be evaluated on a case-by-case basis.

Introduction

Organic crop production in Canada occupies approximately 1.7 million acres, 83% of which reside in the prairie provinces of Alberta, Saskatchewan, and Manitoba (Macey, 2010). Field pea is an important organic crop in the Canadian prairies, and is grown both for grain and green manure. Field peas are known to increase soil reserves of nitrogen and give other yield benefits in rotations (Stevenson and van Kessel, 1996), which are of increased importance in the absence of fertilizers. However, growing peas organically can be challenging, since field pea yields are relatively sensitive to weed presence compared with other crops such as barley and canola (Harker, 2001).

Crop yields may be improved in the presence of weeds by enhancing the ability of the crop to capture resources such as sunlight, nutrients, and water. Crop competitiveness refers to resource capture by the crop relative to the weeds, and is indicated by both the ability of the crop to suppress weeds, and the ability of the crop to yield well while growing with weeds. Although field peas generally are known to be weak competitors, differences exist among cultivars in their resource capture abilities. Long vines (Spies, 2008), and high leaf area index (Wall and Townley-Smith, 1996) are factors that are associated with improved competitive ability for field pea.

The leaf type of field pea cultivars may also affect competitive ability. Field pea varieties grown in the Canadian prairies possess one of two leaf types. Semi-leafless pea, the more common of the two, expresses the recessive afaf gene, which modifies all leaflets to tendrils (Snoad, 1974). Semi-leafless pea is favoured for its high seed yield potential (Harker et al, 2008; McDonald, 2003), and its improved lodging resistance due to the strengthened tendrils (Snoad, 1974). Wild type, or "leafed" pea cultivars are typically grown in the Canadian prairies to generate biomass for forage or green manure. Leafed cultivars are typically more weed suppressive than semi-leafless types, and have higher yield stability when competing with weeds (Harker et al., 2008).

Intercrops and cultivar mixtures refer to growing of multiple crop species, or cultivars of the same species, together in proximity for yield and other benefits. Component crops or cultivars are chosen to complement each other. For field pea, cultivar mixtures may be a tool to combine the high yield potential and lodging resistance of semi-leafless pea, with the weed suppression and yield stability of leafed pea. Yield and weed suppression of intercrops and cultivar mixtures may be affected by both the mixing ratio of the component crops or cultivars, and by the density at which they are sown.

A five site-year field experiment was conducted on organic land near Saskatoon, Saskatchewan, to evaluate mixtures of a leafed and semi-leafless cultivar, sown in different mixing proportions and densities, as a weed management tool for organic producers. It was hypothesized that growing mixtures of leafed and semi-leafless pea would produce weed control and yield benefits compared with growing the same cultivars as monocultures.

Materials and Methods

The experiment was conducted at the Kernen Crop Research Farm near Saskatoon, Saskatchewan, from 2010-12, and in an organic producer's field near Vonda, Saskatchewan, in 2011-12. Treatments were tested against natural weed populations, and weeds were mechanically controlled prior to canopy closure using harrows or a rotary hoe according to standard local practice for organic producers.

The experiment had a two-way factorial treatment design on a randomized complete block. The two factors were target plant densities (88 and 176 plants m^{-2} in 2010, or 88 and 132 plants m^{-2} in 2011-12) and percentage of each of the two cultivars sown (0:100, 25:75, 50:50, 75:25, and 100:0% semi-leafless to leafed). All treatment combinations were replicated four times per site, with the exception of the Vonda 2012 site, which had three replicates.

Cultivars used for the experiment were developed by the Crop Development Centre, University of Saskatchewan. Semi-leafless cultivars CDC Patrick (2010 only) and CDC Dakota (2011-12), and leafed cultivar CDC Sonata (all site-years) were selected for the mixtures based on similarity in vine lengths (80-85 cm), which may affect competitive ability (Spies, 2008; McDonald, 2003;

Wall and Townley-Smith, 1996). The seed of the two cultivars was mixed in the desired proportions before seeding, and the two cultivars were sown into the same rows.

All sites were monitored for crop emergence, final stand density, weed density, weed and crop biomass, and crop yields. Crop and weed counts were taken using two $1m^2$ or $0.25m^2$ quadrats per plot, respectively, approximately two weeks after crop emergence. Weeds were identified and counted by species. Crop and weed biomass was sampled prior to harvest by cutting the above-ground plant material from within two $0.25m^2$ quadrats per plot, oven-drying, and weighing. Plots were combined using a small plot harvester. Seed was cleaned of dockage, separated by cultivar, and weighed.

Data were analyzed using the mixed procedure in SAS (version 9.2, SAS Institute Inc., Cary, NC, USA). The ratios of the two cultivars, seeding rate, and the interaction of the two factors were treated as fixed effects in the model, and site, replicate within site, and interactions of treatment with site were treated as random effects. Only significant treatment effects ($P < 0.05$) are presented.

Results and Discussion

Weeds were abundant at all field sites, and average end-of-season weed biomasses at the different sites ranged from 1645-3046 g ha^{-1}. At each site, wild mustard, common lambsquarters, redroot pigweed, green foxtail, and wild oat comprised 93% or greater of the weed population. Increasing the seeding rate was effective at suppressing weeds for both CDC Patrick ($P = 0.0001$) and CDC Dakota mixtures ($P < 0.0001$). The overall weed biomass reductions with increased seeding rate were 37% and 10% in CDC Patrick and CDC Dakota mixtures, respectively.

For CDC Patrick mixtures, the varietal composition of the mixture did not have an effect on weed suppression, indicating that CDC Sonata and CDC Patrick were equally weed suppressive ($P = 0.9269$). In contrast, semi-leafless variety CDC Dakota suppressed weed biomass more effectively than CDC Sonata ($P = 0.0005$). As the mixture shifted from 0 to 100% semi-leafless, weed biomass decreased by approximately 25% (Fig 1). Lack of a significant quadratic response indicated that mixtures of the two cultivars were not more weed suppressive than CDC Dakota grown alone. The range in weed suppressive abilities among tested cultivars is consistent with previous studies that suggest that leaf type is not a consistent predictor of competitive ability (McDonald, 2003; Wall and Townley-Smith, 1996; Townley-Smith and Wright, 1994).

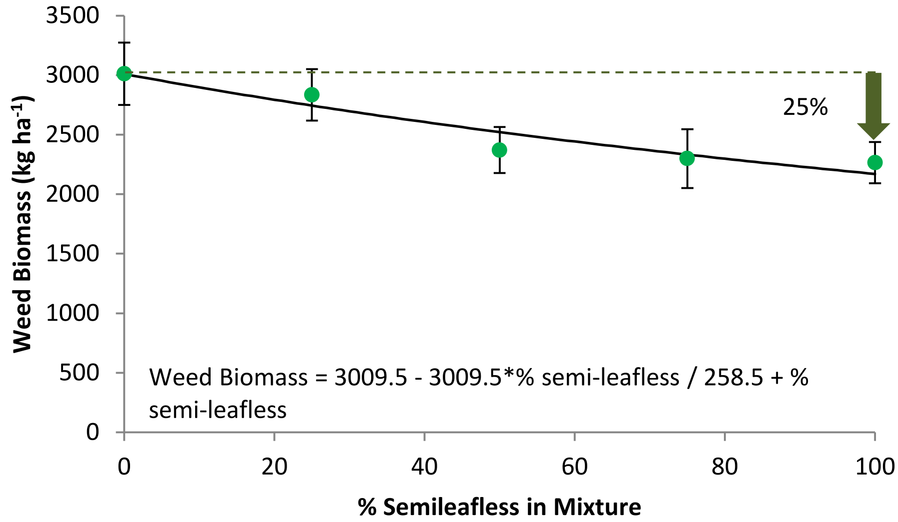

Figure 1: Weed biomass response to percentage of semi-leafless cultivar CDC Dakota in mixture at 2011-2012 field sites in central Saskatchewan. Leafed and semi-leafless cultivar monocultures are represented by 0 and 100% semi-leafless, respectively. Weed biomasses represent treatment means across four site-years (n=15). Error bars represent standard errors of means.

Overall crop yields varied by site and season. At Kernen, yields reached 57-60% of the provincial ten-year average for conventional production (Saskatchewan Ministry of Agriculture, 2012). At Vonda, attained yields were 23-34% of the provincial average of 1947 kg ha^{-1}. Crop yields responded to seeding rate for CDC Patrick ($P < 0.0001$), but not CDC Dakota mixtures ($P = 0.1201$). Yields were increased overall by 8% for mixtures of CDC Sonata with CDC Patrick.

Crop yields were significantly affected by mixture composition for both CDC Patrick and CDC Dakota mixtures ($P < 0.0001$). Monocultures of either semi-leafless cultivar out-yielded CDC Sonata by 83-165%. Total yields of the mixtures increased as the percentage of semi-leafless pea increased (Fig 2a and b). It has been noted in the literature that semi-leafless cultivars are often higher yielding than leafed under weedy conditions, despite suffering greater yield losses due to weed competition (Harker et al., 2008).

Additional yield enhancements above both component monocultures occurred in 75% CDC Dakota mixtures in three of four site-years. The yield improvement amounted to 8-20% above CDC Dakota sole crops. Further investigation showed a highly significant quadratic effect ($P < 0.0001$), with optimal crop yields predicted to be 806.92 kg ha^{-1} in mixtures with 86% CDC Dakota (Fig 2b). Yield benefits over both component monocultures were not seen in CDC Patrick mixtures (Fig 2a). Yield and agronomic advantages have been previously shown in mixtures of 53-67% semi-leafless cultivar 'Solara' in the absence of weeds (Schouls and Langelaan, 1994), but mixture performance in the presence of weeds has not been reported in the literature.

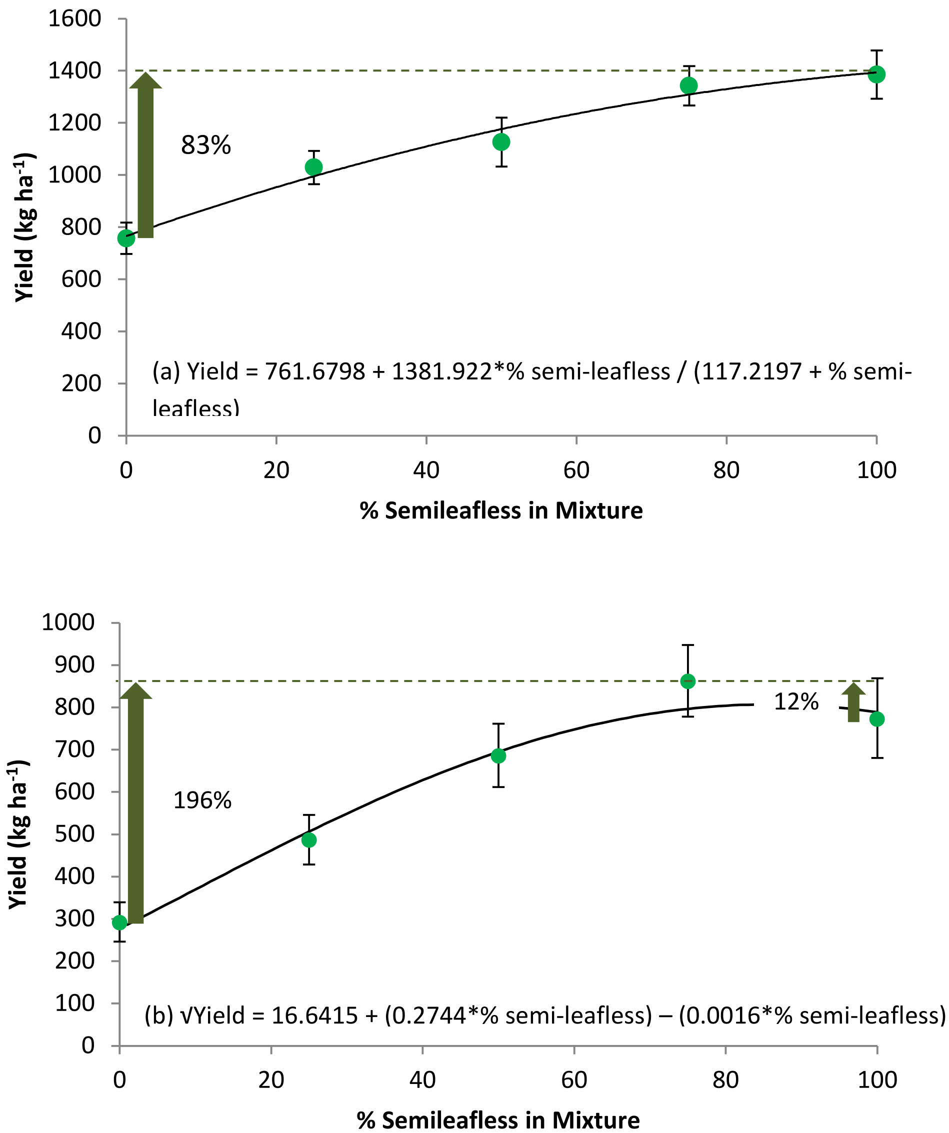

Figure 2: Response of crop yield to percentage of semi-leafless cultivar (a) CDC Patrick or (b) CDC Dakota in mixture at 2010-2012 field sites in central Saskatchewan. Leafed and semi-leafless cultivar monocultures are represented by 0 and 100% semi-leafless, respectively. Weed biomasses represent treatment means in 2010 for CDC Patrick (n=4), and in 2011-12 for CDC Dakota (n=15). Error bars represent standard errors of means.

Conclusions

The results of this study indicate that it is possible to increase organic field pea yields in the presence of weeds by growing mixtures of leafed and semi-leafless pea. Benefits of mixtures were dependent upon the specific cultivars comprising the mixture, and the ratio at which they were combined. In this study, maximum yields were observed in mixtures of 75% CDC Dakota with 25% CDC Sonata, however no benefits were seen when CDC Patrick and CDC Sonata were grown in mixtures. Results indicate that specific combinations of leafed and semi-leafless cultivars should be evaluated case-by-case.

Mixtures did not improve weed control compared with monocultures of component cultivars. The experiment, however, demonstrated a range in the weed-suppressive abilities of field pea cultivars, which was not easily attributed to leaf type. Semi-leafless cultivars CDC Patrick and CDC Dakota were either equally suppressive to, or more weed-suppressive than leafed CDC Sonata, respectively. In the presence of weeds, both semi-leafless cultivars out-yielded leafed CDC Sonata. Taking these results together, this study concurs with other research in demonstrating that the benefits of growing semi-leafless pea cultivars extend to weedy conditions.

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