WEED MANAGEMENT IN ORGANICALLY-GROWN NARROW-LEAFED LUPIN

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ABSTRACT

Weed management is necessary to obtain acceptable seed yields in organically cultivated lupins. Two varieties of narrow-leafed lupin (*Lupinus angustifolius* L.), with different branching characteristics, were sown in replicated plots at two sites in Sweden. The branching cv. Bora and the single-stemmed cv. Prima were organically grown at two inter-row distances of 12 and 25 cm. The effect on seed yield and weeds of weed harrowing before crop emergence supplemented with weed harrowing after emergence at a row distance of 12 cm was studied. At 25 cm, row distance weeds were managed by harrowing before crop emergence and supplemented by later inter-row hoeing. Due to unfavorable weather conditions at one site, not all of the control measures could be performed. Untreated controls were included. Seed yield responded similarly to the treatments at both sites. In untreated controls, the seed yield of cv. Bora was 2,725 kg ha^{-1} and the inter-row distance did not influence it. The yield of cv. Prima fell from 2,520 kg ha^{-1} at 12 cm to 2,245 kg ha^{-1} when sown in 25 cm rows. Weed management did not influence the seed yield of cv. Prima but reduced the yield of cv. Bora by 300 kg ha^{-1}. Averaged over weed management strategies, the weed weight at one site was 85% higher in cv. Prima grown in 25 cm rows than in all other treatments. At the same site, where *Stellaria media* L. Vill. constituted 30% of the weed flora, only inter-row hoeing significantly ($P < 0.05$) reduced weed weight. At the other site, where the weed flora was dominated by *Chenopodium album* L., the weed weight in cv. Bora was 13-46% lower at an inter-row distance of 12 cm than in all other treatments. At this site, the weed weight was reduced only by weed harrowing and not by inter-row hoeing. It was concluded that the efficiency of different weed management strategies varied between sites and with different weed floras.

KEYWORDS

Weeds, inter-row hoeing, weed harrowing, organic farming

INTRODUCTION

The Swedish government set the goal in 1999 that 20% of arable land should be organically farmed by 2005. Organic farming was defined as cultivation without the use of pesticides or chemical fertilizers. To maintain soil fertility, the ban on chemical fertilizers makes it necessary to include nitrogen-fixing species in crop rotations. To reduce the need for imported protein supplements for animal production there is also a desire to increase domestic fodder production.

Pea (*Pisum sativum* L.) and faba bean (*Vicia faba* L.) have traditionally been the only two forage/grain legumes that could be grown successfully in Sweden. In the last few years, where peas have been cultivated with intervals of less than 6-8 years, there has been increased problems with pea common root rot (*Aphanomyces euteiches*). Studies showed that *A. euteiches* can survive on species other than pea, e.g. faba bean, alfalfa (*Medicago sativa* L.) and on some weed species (Chan and Close, 1987; Grau *et al.*, 1991). As there is no evidence that *Lupinus* spp. can act as an alternate host for the disease lupin cultivation can give a valuable break in the crop rotation.

Thus, new early maturing, low alkaloid, varieties of *Lupinus angustifolius* are of great interest to Swedish organic farmers. Compared with other agricultural crops grown in Sweden the time to seed maturity is comparatively long for lupins. Their development time varies with cultivar and is influenced by day length and temperature (Reader *et al.*, 1995; Christiansen and Jørnsgard, 2002). Experience of growing lupins in Sweden is limited but it is likely that their cultivation will only be possible in the south of the country.

During early development, narrow-leafed lupin is a weak competitor and allows high light transmission through the crop canopy to the weeds below. Since the use of herbicides is not allowed in organic farming, the development of efficient mechanical weed-management strategies is required. This is necessary not only to obtain acceptable lupin seed yields but to also reduce the addition of weed seed to the soil seed-bank.

IN E. van Santen and G D. Hill (eds). Mexico, Where Old and New World Lupins Meet. Proceedings of the 11th International Lupin Conference, Guadalajara, Jalisco, Mexico. May 4-9, 2005. International Lupin Association, Canterbury, New Zealand. ISBN 0-86476-165-1

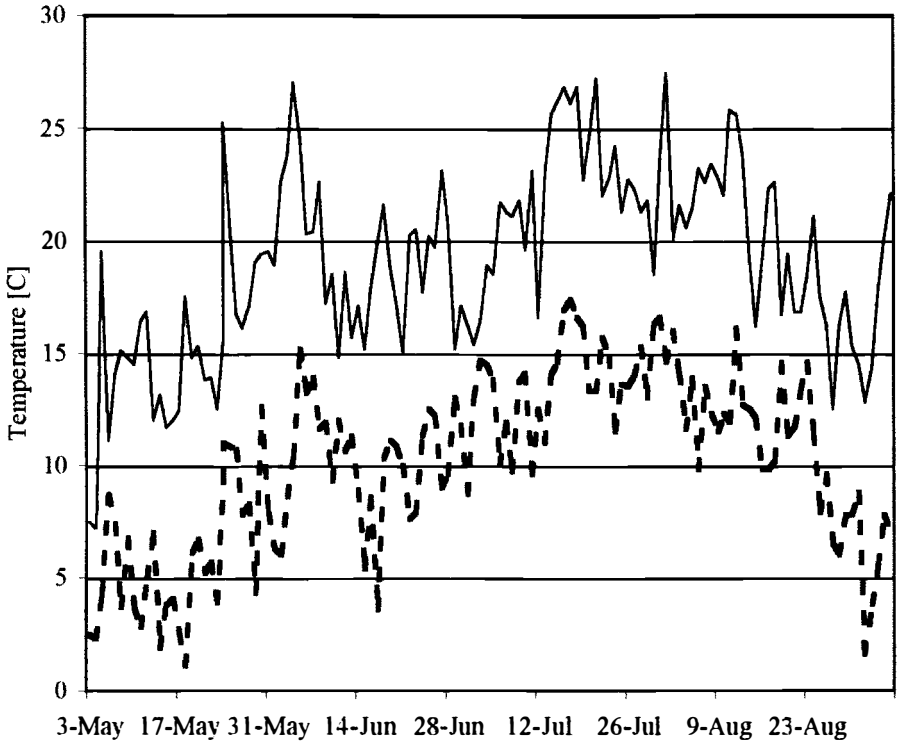

Fig.1. Daily high and low temperature at the Jung location.

The two trials reported here were initiated to evaluate two weed management strategies in lupin: cultivation either at the normal inter-row distance (12 cm) and utilizing weed harrowing to control weeds, or seeding at an inter-row distance of 25 cm and using inter-row hoeing for weed control. These strategies were applied to two lupin cultivars, one of which was single-stemmed and one that also sets pods on branches.

MATERIALS AND METHODS

Two field trials using different weed management strategies were established in the south of Sweden in 2003 with two varieties of *Lupinus angustifolius*. cv. Prima, which produces pods only on the main stem, and cv. Bora, which also produces pods on branches. The trials were located on organically farmed land at Skea (56° 09' N, 13° 46' E) and Jung (58° 31' N, 15° 30' E). The daily temperature at 2 m height and rainfall was recorded at 13 km from the experimental site at Jung (Fig. 1). Plot-size was 70 m^2 at Jung and 90 m^2 at Skea. The experimental design was a completely randomized block with four replicates.

Table 1. Treatment dates for seeding, mechanical weed control, and harvest.

		Soil cultivations			
Site	Seeding	Before crop emergence	1st	2nd	Harvest
Skea	15-Apr	23-Apr	7-May	17-May	Sept. 5
Jung	3-May	not performed	30-May	not performed	Sept. 9

At the 12 cm inter-row distance the sowing rate was 130 plants m^{-2}, while at 25 cm the sowing rate was reduced to 90 plants m^{-2} to reduce intra-specific competition. At Skea, both treatments were weed harrowed once before crop emergence (Table 1). Due to rain it was not possible to perform early weed harrowing at Jung. Despite this there were few weeds at Jung, and it was decided to exclude the second weed harrowing and the inter-row hoeing. One untreated control sown at each of the two row-distances was included in the trials.

The seed yield from the center of each plot was estimated using a combine-harvester. The harvested area was 24 m^2 at Jung and 30 m^2 at Skea. Final seed yield was corrected for screenings and adjusted to 15% moisture.

Weeds were sampled in four 0.25 m^{-2} quadrats about six weeks after the last soil cultivation. The harvested weeds were separated into species, counted and weighed.

The data from the two field sites were analyzed together by analysis of variance (ANOVA) using the Mixed Model Procedure (SAS, 1997) to test for main effects (fixed: site, cultivar, row distance and weed management; random: block) and interactions. Significant mean treatment effects were separated using LSD at the 95% confidence level.

RESULTS AND DISCUSSION

Growing conditions in 2003 were favorable for lupin growth. The average air temperature in June and July at Jung, was 16.6°C and the total rain fall from May to September was 110 mm.

SEED YIELD

The seed yield of Bora ranged from 2,300 to 3,000 kg ha^{-1} and the seed yield of Prima was 2,000 to 2,600 kg ha^{-1}. This is higher than reported from cultivar-testing trials in Sweden in 2001, where the yield of Bora varied between 350 and 2,030 kg ha^{-1} (mean: 1,180 kg ha^{-1}). The mean yield of Prima was 980 kg ha^{-1} (pers. comm., Staffan Larsson, SLU). In 2002, most of these cultivar trials were damaged by roe deer and hares and few reliable lupin yields were obtained.

There were significant interactions for site x weed management ($P < 0.001$) and site x inter-row distance ($P < 0.05$). At Skea there was no influence of inter-row distance on seed yield. At Jung seed yield decreased by 300 kg ha^{-1} when the inter-row distance was doubled. At Skea, weed

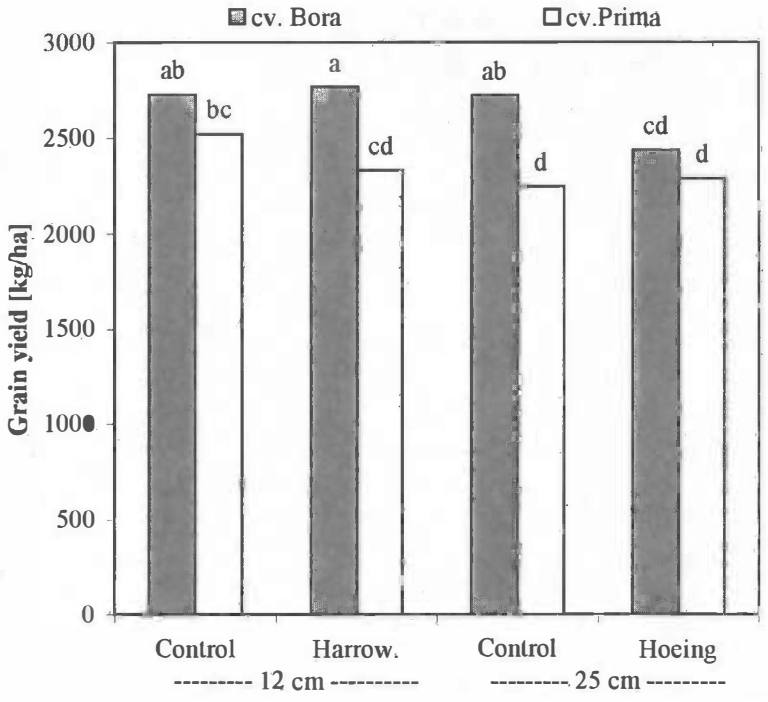

Fig. 2. Grain yield of two lupin cultivars after weed harrowing at a row distance of 12 cm or inter-row hoeing at 25 cm row distance and in the controls.

management reduced yield by 300 kg ha^{-1}, while at Jung weed management had no effect on yield averaged over row distances and cultivars. There is a risk that harrowing and inter-row hoeing may damage the crop. However, Danish experiments showed that lupin is very tolerant to intense and repeated harrowing and is also tolerant of high crop soil cover (Jensen *et al.*, 2000; Jensen *et al.*, 2004).

Over the two field sites, Prima seed yield was reduced by 190 kg ha^{-1} with increased inter-row distance in untreated control plots (Fig. 2). There was no effect on Bora yield in response to inter-row distance. It seems that Bora, which produces pods on its branches, tolerates a wide inter-row distance better than the single-stemmed Prima.

Weed management reduced weed weight at Skea but did not influence the yield of Prima or Bora when sown at a 12 cm inter-row distance. This suggests that any crop injury caused by cultivation may be compensated for by reduced weed competition. Inter-row hoeing in Bora reduced seed yield by 290 kg ha^{-1}. Inter-row hoeing in 25 cm inter-rows requires high precision and is difficult to perform without crop damage.

Weed weight

Weed biomass in untreated control plots can be interpreted as a result of the crop's ability to suppress weeds. At Jung total weed weight doubled in the untreated controls when the inter-row distance was increased ($P < 0.05$) (Fig. 3). At Skea the total weed weight in the control plots was not influenced by inter-row distance.

Inter-row hoeing but not harrowing had a significant ($P < 0.05$) negative effect on total weed weight at Jung (Fig. 3). Harrowing favored *Stellaria media* L. Vill.; the weight of the species increased from 40 to 100 g m^{-2}. At Jung, harrowing was only performed once and it is possible that this single cultivation stimulated weed seed germination. At Skea, the results were opposite: harrowing but not inter-row hoeing significantly ($P < 0.001$) reduced weed weight. Both European field pansy (*Viola arvensis* Murr.) and common lambsquarters (*Chenopodium album* L.) were better controlled by harrowing than by hoeing. These two species together were 85 % of the total weed weight in control plots. It is possible that weed plants growing within the rows and surviving after inter-

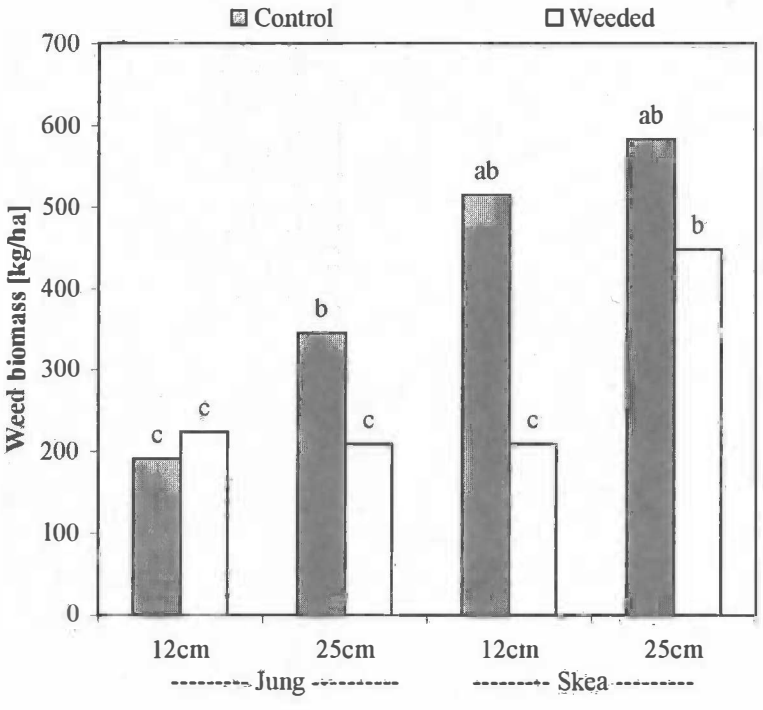

Fig. 3. Total weed weight after weed harrowing at a row distance of 12 cm or inter-row hoeing at 25 cm row distance and in untreated controls.

row hoeing were favored by reduced intraspecific competition.

A significant ($P < 0.05$) site x cultivar x inter-row distance interaction showed that weed weight increased with inter-row distance independently of weed-management (Fig. 4). Doubling the inter-row distance at Jung significantly ($P < 0.05$) increased weed weight in Prima but not in Bora. At Skea, the weed weight was only increased by a doubled inter-row distance in Bora ($P < 0.05$). This difference may have been due to the different weed flora at the two sites.

At Jung, Prima was less competitive than Bora against common chickweed (*Stellaria media*) when sown in 12 cm inter-rows. At Skea, Prima was less competitive than Bora against black bindweed (*Bilderdykia convolvulus* L.) and shepherd's purse (*Capsella bursa-pastoris* L.). The weight of other weed species was not affected by lupin cultivar. The differing competitive effect among lupin cultivars varieties was shown by Hashem *et al.* (2004).

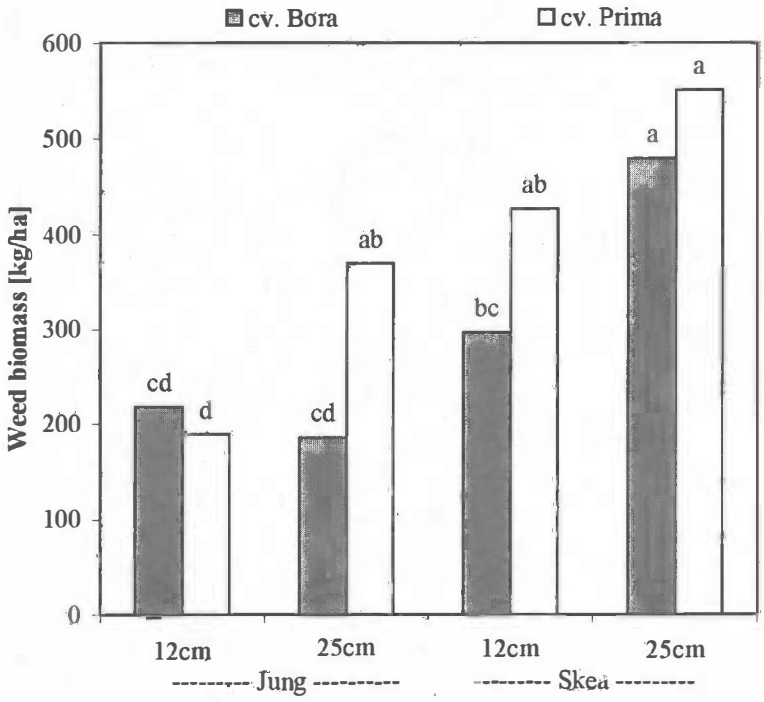

Fig. 4. Total weed weight in two varieties of narrow-leafed lupin sown at two sites at the row distances 12 cm and 25 cm.

This study shows the need for weed management in the lupin crop. Although weed management did not always increase seed yield, it was necessary in order to reduce the addition of new weed seed to the soil seed-bank. The results also show that the efficiency of harrowing and inter-roe hoeing varies among weed species. It would appear to be possible to cultivate lupins sown at wider inter-row distances than are normally used for cereals in Sweden, thereby reducing the seeding rates without any reduction in seed yield.

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