New annual legume crops for Finnish conditions

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Abstract

Legumes are an important component of sustainable crop rotations around the world, but are under-represented in European agriculture. Finnish use of grain legumes is exceptionally low. These experiments were initiated to test the possibility of extending the range of grain legumes that can be grown in Finland. A small range of germplasm of blue lupin, white lupin, lentil and some other annual species were tested in a trial that also included familiar cultivars of faba bean. Faba bean yields were 6.0 – 7.3 Mg ha^{-1}, blue lupin yields 3.3 – 4.8 Mg ha^{-1}. Two of the cultivars of blue lupin reached maturity in a timely fashion, showed little disease and did not lodge, so they have potential for use in the national agricultural system. Lentils also ripened, but presented management problems that require further investigation. White lupin showed potential as a producer of biomass, with one cultivar exceeding 18 Mg ha^{-1} dry matter.

Key words: blue lupin, faba bean, fenugreek, lentil, narbon bean, soy bean, white lupin

Introduction

Legumes are a key part of the ecological intensification (Cassman 1999) of agriculture. They provide symbiotically fixed nitrogen, so not only are they free of the need for nitrogen fertilizer, they also contribute to the nitrogen nutrition of the following crop. A grass-free legume crop breaks soil-borne cereal disease cycles. Legume root exudates enhance the growth of many beneficial soil organisms. Grain and forage legumes can be locally grown to provide stockfeed rich in protein, energy and bioactive compounds, without the need for long-distance shipment. Legumes add to the options available to the farmer, improving farm viability; they increase regional biodiversity and landscape diversity, and they support pollinating bee populations. The net release of nitrous oxide (N_2O, a powerful greenhouse gas) in two years of a legume-supported crop rotation was only 54% of that of a continuous cereal rotation in central North America (Dusenbury et al., 2008). In spite of these benefits and in the context of agricultural intensification, the cultivation of legume crops has gone through a long decline in Europe, leading to a dependence on protein imports (Stoddard et al., 2009). Recent increases in many agricultural commodity prices, including fertilizer and soybean meal, have rekindled grower and processor interest in both grain and pasture legumes.

Legumes and products made from them have health-affecting attributes that are particularly important for the Finnish population. The cholesterol-reducing effects of legume storage proteins were first identified from soybean (*Glycine max* (L.) Merr.) (Sirtori et al., 1998) and have since been extended to white lupin (*Lupinus albus* L.), which has also shown benefits to atherosclerosis and blood lipid levels (Marchesi et al., 2008). Whole flour of blue lupin (*L. angustifolius* L.) has been shown to have blood pressure-lowering effects (Lee et al., 2009). The starch of grain legumes is generally slowly digestible, contributing to colon health, and they are rich in dietary fibre. Lupin grains are particularly rich in dietary fibre, as they store beta-galactan rather than oil or starch. Lupin fibre and lupin protein, mostly from blue lupin, are being developed as functional food additives in Australia.

For these reasons, experiments were initiated to test the suitability of a range of legumes to Finnish agricultural conditions. These experiments formed part of the MoniPalko cooperative research project funded by Ministry of Agriculture and Forestry.

Materials and methods

Blue lupin cvs Haags Blaue, Boruta, Boregine and Sanabor were obtained from Saatzucht Steinach, Germany. Lentil (*Lens culinaris* Medik.) cvs Plato, Redberry, Robin and Viceroy were obtained from the Crop Development Centre, University of Saskatchewan, Canada. Faba bean (*Vicia faba* L.) cvs Kontu, Aurora, Mélodie and Jõgeva were obtained from Boreal, Naturcom, Agri-Obtentions (France) and Jõgeva Plant Breeding Institute (Estonia), respectively. White lupin cvs Amiga and Vesna were obtained from Naturcom and Novi Sad Plant Breeding (Serbia), respectively. Soybean cvs Lana and Gracija, along with samples of fenugreek (*Trigonella foenum-graecum* L.) and narbon bean (*Vicia narbonensis* L.) were obtained from Novi Sad Plant Breeding.

Appropriate rhizobium inoculants were obtained from Elomestari and were applied to the seeds before planting, except for soybean for which no inoculants was available. The experiment was laid out as two randomized complete block trials with four replicates at Viikki, Helsinki. Plots were 2.5 m wide and 6 m long. Row spacing was 25 cm in all cases and seed spacing was adjusted to provide the growing densities recommended by the breeders.

Faba bean, lentil and blue lupin were sown in the first trial on 7 May 2009 and the white lupin and soybean in the second trial, along with unreplicated plots of the other species, on 27 May 2009. Data on emergence, flowering, radiation interception, disease incidence, bee activity and maturity were collected during the growing season. A subplot of 1 m^2 was manually collected from each plot for analysis of yield components at crop maturity or, from non-maturing plots, at first frost, and the remainder of each faba bean and blue lupin plot was machine harvested on 1 October.

Experiments of faba bean, blue lupin and lentil were established at MTT Research Station in Mikkeli, as well. Because of some problems with seeds and inoculants, the trials were sown 2 weeks later than in Viikki. Late sowing contributed to difficulties in controlling weeds, so only some faba beans matured.

Results

The tested faba bean germplasm offered no earliness advantages over the available national cultivar Kontu, although cv Aurora was higher yielding (Table 1). The blue lupin germplasm presented a range of maturity dates, with Haags Blaue being 8 days earlier than faba bean cv. Kontu (Table 2). Lentils flowered uniformly on 29 June but did not stop flowering. Pigeons did considerable damage to the plots as the early pods reached maturity.

Disease pressures in the plots were low. Initial signs of botrytis diseases on the lentils and faba beans led to the whole trial being treated with Tilt® fungicide on 7 August.

White lupin continued to flower from 15 July (Amiga) or 18 July (Vesna) until hard frost in early October. Cultivar Vesna covered the ground before cv Amiga and weed growth under both cultivars was effectively suppressed. Vesna produced 18.2 Mg ha^{-1} of dry matter and Amiga 10.8 Mg ha^{-1} (standard error 0.7 Mg ha^{-1}). As in previous years, dry matter production of faba bean cv Aurora exceeded that of white lupin cv Amiga, but cv Vesna greatly outyielded anything else in the trial.

Soybean cv Gracija flowered on 3 August and produced almost mature pods by the time of first frost at the end of September, with a total dry matter yield of 3.0 Mg ha^{-1}, and cv Lana flowered from 6 September and produced 4.3 Mg ha^{-1}. Narbon bean and fenugreek produced relatively small plants that lodged badly and were not harvested, although at least some seeds on each matured.

Table 1. Faba bean flowering date, maturity date and key yield components.

Cultivar	Flowering date (10%)	Maturity date (90%)	Yield (Mg ha^{-1})	Seed size (mg)	Seeds / pod	Total dry matter (Mg ha^{-1})
Kontu	22 June	22 Aug.	6.29	400	3.60	10.4
Jõgeva	19 June	25 Aug.	6.04	880	3.00	10.2
Aurora	29 June	5 Sept.	7.33	570	3.60	12.8
Mélodie	30 June	14 Sept.	6.30	690	3.20	10.9
SE			0.35		0.05	0.6

Table 2. Blue lupin flowering date, maturity date and key yield components.

Cultivar	Flowering date (10%)	Maturity date (90%)	Yield (Mg ha^{-1})	Seed size (mg)	Seeds / pod	Total dry matter (Mg ha^{-1})
Haags Blaue	23 June	14 Aug.	3.28	176	3.60	7.3
Boruta	28 June	27 Aug.	3.94	166	4.90	8.8
Boregine	26 June	13 Sept.	4.08	182	3.90	9.4
Sanabor	27 June	23 Sept.	4.82	203	4.60	10.3
SE			0.23		0.15	0.5

Discussion

Faba bean was included in the trial as an established benchmark against which other legumes could be compared. Yields were higher than the national average (Boreal Plant Breeding expects 3.5 Mg ha^{-1}), as is usually the case in small plots. The Swedish cultivar Aurora offered a yield advantage over the Finnish cultivar Kontu, at the cost of a probably unacceptable 10 day delay in ripening. Modern international cultivars will be tested in the coming year.

Although the blue lupin yields were lower than those of faba bean, cultivar Haags Blaue was considerably earlier in maturity and so could be cultivated in zones with shorter season than faba bean. Cultivar Boruta was comparable in maturity to faba bean cv Kontu and was much higher yielding than cv Haags Blaue. The ease of sowing and harvesting of blue lupin, on account of its small seeds and strong resistance to lodging, along with its higher protein content (usually 35%, in contrast to the 30% common in faba bean), make it an attractive crop for light sandy soils. Blue lupin has clear potential for development as a grain legume in Finnish conditions.

Lentil matured at least some seeds, but its standing power was very poor. Management systems will need to be devised and further germplasm screened in order for Finnish farmers to take advantage of the high world price and demand for this crop.

The excellent ground cover, robust standing power, and high dry matter production of white lupin are properties that show that this crop has potential as a break crop that can potentially reduce weed populations while fixing a large quantity of nitrogen.

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