Warm season crops for cool season agriculture: potential of common bean and soybean in the northern wheatbelt of WA

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Key messages

Phaseolus beans (common bean) have potential yields of approximately 1.1 tonnes/ha in northern agricultural region with mild winter temperatures, based on preliminary yield trials.

Soybean was more cold temperature susceptible than bean and has less potential unless breeding can provide improved cold tolerance and appropriate phenology.

Further larger scale trials and an economic feasibility assessment will be required for beans to assess the profitability of the crop in the northern agricultural region.

Aims

This study assessed the growth of the warm season crops common bean and soybean under winter field conditions of the northern wheatbelt of Western Australia in order to determine their yield potential relative to the adapted winter grain legume, lupin.

Background

Although a crop plant has its natural temperature range for growth and grain production, a wide range of genetic diversity can exist to allow selection for lower or upper extremes within the species. Common bean is tropical and sub-tropical in origin and considered a warm season crop species (Holubowicz and Dickson 1989) being adapted to average diurnal temperatures of about 16 to 25°C (Drijfhout et al., 1991), which tends to be lower than for many other warm season crops. However, its genetic diversity and adaptation to a range of ecological niches suggest potential flexibility in its suitability to different growing environments (Acosta-Gallegos et al., 2008; Mamidi et al. 2011). Soybean is considered a tropical crop with growth temperature optima lying between 20-30ºC. Studies investigating cold tolerance in soybean at different growth stages are extensive and have assisted the selection and development of soybean genotypes for earlier sowing or improved performance in summer cropping systems, for example in the USA and Canada, and higher altitude regions in some countries where more reliable germination, plant establishment, canopy development and yield are required.

Crop diversification through the use of break-crops has provided significant benefits to the farming system where wheat is the major crop in productive agriculture, for instance in Western Australia. Legumes such as lupin, pea and chickpea provide a disease break as well as residual nitrogen through symbiotic fixation (Seymour et al., 2012).

The present study endeavoured to assess, for the first time, the growth of the warm season crops common bean and soybean as potential alternative legumes under winter field conditions of the northern wheatbelt of Western Australia

Method

The location for field trials in 2011 and 2012 was a sandy loam paddock, pH 6.5, on Mr Chris Gillam's farm property, 10 km east of Dongara, Western Australia where the coldest winter month average daily maxima and minima of approx. 18 and 8°C respectively are experienced. In both years, experimental plots consisted of 4 rows, 2 m long, with rows 45 cm apart, with seed sown at approximately 5 cm spacing, establishing 35-40 plants per m2. There were 3 replications. Seed was hand-sown to a depth of 2 cm.

In 2011, fertilizer (NPK Blue) was applied at 200 kg/ha so as to not rely on rhizobial symbiosis, although nodulation did occur on the lupin genotype (due to a paddock history of lupin having been grown in the past). The experiment consisted of 15 genotypes: 5 *Phaseolus vulgaris* (phaseolus bean, all South African cultivars), 9 *Glycine max* (soybean) and 1 *Lupinus angustifolius* (narrow-leafed lupin control, cv. Mandelup). The design was a randomized complete block, with 3 replications. Seed was sown on 30/05/2011.

In 2012, 10 genotypes were included: 7 *P. vulgaris* (5 South African genotypes as per 2011, and 2 Australian genotypes), 2 *G. max* genotypes and 1 *L. angustifolius* (control, cv. Mandelup). The design was a split plot, with nitrogen supply (fertilizer or rhizobium inoculum) as main plots, and genotypes as subplots. The N, minus inoculum nitrogen (full fertilizer, plus urea, -Rrhizobium) treatment was urea, superphosphate and potash (KCl) at the kg/ha rates of 80, 30 and 50 respectively. The plus rhizobium (+Rhiz and without nitrogen) treatment consisted of inoculation with Group G, *Rhizobium tropici* (strain CC511), and Group H for lupin, bean and soybean respectively, applied by dissolving excess quantities of inoculant product in water and watering over seed in furrows prior to covering to sowing depth with soil. Minus inoculum (N) plots received a water only treatment, being careful not to cross contaminate blocks. Rhizobium treatment plots then received top-dressed P and K fertilizers only at the rates as per the minus rhizobium treatment.

Results

Results from 2011 (Table 1) indicated significant differences among genotypes for seed yield and harvest index, with lupin producing yields well above either beans or soybean. The highest yielding genotype of beans was approximately 1.1t/ha based on small plots within this study.

Table 1 Seed yield and harvest index of bean and soybean genotypes in the field at Dongara in 2011.

Genotype	Crop	Seed yield (kg/ha)	HI
Dongara	Phaseolus bean	1036	0.51
Gadra	Phaseolus bean	557	0.46
Kariba	Phaseolus bean	1164	0.48
Sibaya	Phaseolus bean	942	0.50
Ukulinga	Phaseolus bean	946	0.54
Altom	Soybean	89	0.20
Bunya	Soybean	396	0.20
Fiskeby V	Soybean	45	0.17
Fraser	Soybean	68	0.07

Genotype	Crop	Seed yield (kg/ha)	HI
Major	Soybean	106	0.30
Melrose	Soybean	131	0.19
Oakey	Soybean	228	0.24
PI291272	Soybean	26	0.10
UK	Soybean	22	0.07
Mandelup	Narrow-leafed lupin	3071	0.32
LSD(0.05)		391	0.07

In 2012 (Table 2), narrow-leafed lupin again yielded far above the other crop species. One genotype of phaseolus beans achieved reasonable yield, although there was variability of performance of both bean and soybean genotypes between the 2011 and 2012 years due to weed control issues. There was no significant effect of nitrogen source (applied N or rhizobial nitrogen fixation) on yield but with significantly higher harvest index ($P<0.05$) for the rhizobial treatment. Overall, harvest index was higher in phaseolus than in lupin or soybean.

Table 2 Seed yield and harvest index (HI) of bean and soybean genotypes for nitrogen (N) and rhizobium inoculated (Rhiz) treatments in the field at Dongara in 2012.

		Yield (kg/ha)		HI	
Genotype	Species	N	Rhiz	N	Rhiz
Arwon	Phaseolus bean	264	365	0.18	0.25
Dongara	Phaseolus bean	384	422	0.34	0.32
Gadra	Phaseolus bean	347	479	0.29	0.45
Haromfa	Phaseolus bean	372	416	0.33	0.32
Kariba	Phaseolus bean	1171	880	0.51	0.55
Sibaya	Phaseolus bean	492	1007	0.42	0.58
Spearfeld	Phaseolus bean	496	333	0.38	0.27
Ukulinga	Phaseolus bean	592	629	0.49	0.61
Bunya	Soybean	45	45	0.02	0.02
Ridley	Soybean	319	683	0.15	0.15
Mandelup	Narrow-leafed lupin	2335	2861	0.34	0.40
LSD(0.05)		396		0.11	

Discussion

Attempting to grow phaseolus beans in a Mediterranean-type climate winter growing season is a new concept for a species that is typically grown in a warm or summer season in Mexico, Europe, North and South America, and in South and central eastern African countries. Production is also reported in the mild winter seasons in regions of the humid subtropical and tropical states of Brazil such as Mato Grosso do Sul and Minas Gerais. Average winter temperatures in the Western Australian northern wheatbelt less than 60 km from the coast may suit the growing of a warm season crop such as phaseolus beans, whose optimal temperatures are lower than for other warm season crops such as corn and soybean.

Weed control in these small field plot experiments was by hand and some weed competition (particularly wild radish and capeweed) did affect variability of results. In preliminary work, beans appear to handle grass weed herbicides well. However, more research will be required particularly for broad leafed weed control and herbicide tolerance of phaseolus beans. The results showed cv. Kariba, of South African origin, to produce the highest yield among the bean genotypes. The study included two Australian canning bean types from Queensland. Although beans yielded far lower than lupin, the higher price for beans (eg. canning beans, $1,000/tonne) may make them a viable crop, depending on markets, transport costs and further development of bean agronomy to achieve higher and reliable yields. There is the potential to breed for cold tolerance in beans.

Conclusion

Phaseolus beans may have potential as an alternative legume crop for milder winter cropping in more coastal regions in the northern wheatbelt of Western Australia. Further assessment of cold tolerant varieties or crosses with best cold tolerant germplasm sources may show greater yield potential. A more comprehensive assessment of bean agronomy, production, weed control options and potential pest and diseases should be worthwhile.

Key words

Phaseolus vulgaris, *Glycine max*, *Lupinus angustifolius*, narrow-leafed lupin

References

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