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Dry matter yields and quality of organic lupin and lupin/cereal mixtures for wholecrop forage

By W M AZO[1], G P F LANE[1], N C CANNON[1] & W P DAVIES[1]

[1]*Royal Agricultural College Cirencester, GL7 6JS, Uk*

Summary

In view of climate change predictions and the general desirability of increasing the amount of home grown protein, a case exists for the investigation of lupins and lupin/cereal bicrop combinations as wholecrop forage on organic farms. A replicated randomised block trial is described which took place at the Royal Agricultural College, Cirencester, in 2005. This involved spring sown blue, white and yellow lupins, millet, wheat and triticale and lupin/cereal bi-crops. Data for dry matter yields for wholecrop silage, crude protein, MAD fibre content and estimated ME, are presented for a single harvest. It is concluded that white lupins and white lupin bi-crops with spring wheat or triticale offer the best prospects for a viable wholecrop forage crop in an organic situation.

Key words: Bi-crop, organic, wholecrop, spring-sown lupins, lupin/cereal mixtures

Introduction

Livestock production requires a continuous supply of quality herbage. The main feed produced for livestock in the UK is grass (Sheldrick, 2000) with a substantial increase in the amount of cereals utilized for forage since the early 90s (Phipps, 1994). Furthermore, climate change predictions (e.g. Hopkins, 2002) suggest an increase in a move to "non-grass forage", in particular in areas subjected to summer droughts. Limitations on the growth of forage maize, particularly on organic farms, and its deficiency in protein, may encourage further the popularity of cereal / legume mixtures. The high cost of imported (GM free) vegetable protein adds further interest to this topic.

Under organic conditions and on suitable soils, lupins offer an opportunity for the production of high protein forage, whilst at the same time providing some fertility in the form of nitrogen fixation (Hall *et al*., 2003). In their unprocessed forms, lupins have many desirable characteristics for feeding livestock. These benefits have been shown in a wide range of situations (Froidmont & Bartiaux-Thill, 2003). Yet like most legume crops the spatial variation and inconsistent performance of lupin remains a major challenge, which restricts the confidence of farmers in lupin based systems. If reliability on forage lupin is to be improved or extended, an in-depth knowledge of their performances and the most efficient way of production and utilisation is required.

Bi-cropping offers an efficient use of land, time and space in livestock production systems. The ability of farmers to grow two crops on the same piece of land and in the same growing season make legume / cereal bi-cropping well suited to sustainable livestock production (Kwabiah, 2004). In South Africa, lupins mixed with oats or wheat produced 20% more combined dry matter yield than when each crop was grown separately (Nel, 1965). Hassan *et al*. (1986) found that an oat / lupin bicrop yielded more dry matter and crude protein per hectare than monocrop oats. In Europe lupin / cereal bicrops have shown similar advantages (Chapot, 1990; Palmason *et al*., 1992), but Jannasch & Martin (1999) reported that lupin and oat or wheat bicrops yielded less than their respective monocrops and Carruthers *et al*. (2000) showed that lupin was a poor competitor with corn (maize) in an intercrop. The dearth of information on the potential of lupins or lupin / cereal mixtures on organic farms warrants their study as an alternative organic forage crop for the UK. The objective of this study was to determine optimum combinations of lupins and spring sown cereals for wholecrop forage in an organic situation.

Materials and Methods

A field trial was undertaken on organic land at the RAC's Harnhill Manor Farm near Cirencester during the spring cropping season in 2005. Soil pH was 6.8 and some weed control was achieved by a stale seedbed technique and delayed drilling. Weather conditions in the spring of 2005 created conditions that delayed spring drilling for between 2 and 3 weeks. The trial was conducted using a randomised block design with four replicates. Mono-crops and bi-crop combinations were established of three species of lupins; *Lupinus albus*, cv. Dieta, *Lupinus angustifolius*, cv. Bora and *Lupinus luteus*, cv. Amber and cultivars of three species of cereals; Wheat (*Triticum aestivum*, cv. Paragon), Millet (*Pennesitum americanum*, cv. Mammoth) and Triticale (*Triticosecale* Wittmark., cv. Logo). The crops were drilled on 25 April and whole-crop harvested from quadrats of 50 cm × 50 cm on 17 August 2005. At harvest the lupins were in the pod ripening stage (white lupin had seeds filling 75% of space between septa while the yellow and blue lupins pods were turning khaki in colour) and the cereals were at the soft dough stage. Fresh weights were taken to determine total biomass and samples oven dried at 100^{o}C for 24 h. Dried samples were then sub-sampled and milled to pass through a 0.1 mm sieve and saved for chemical analysis. Samples were analysed for crude protein, modified acid detergent (MAD) fibre and ether extract, using the procedures and methods of the Association of Analytical Chemists (AOAC, 1980). ANOVA was completed using GenStat 7th edition.

Results

Table 1. *Dry matter yields of spring sown lupins, cereals and lupin / cereal bi-crops*

Mono-crops		Bi-crops	
	DM yield t ha^{-1}		DM yield t ha^{-1}
Yellow lupin cv. Amber	6.41^{bc}	Amber / Mammoth	6.22^{bc}
Blue lupin cv. Bora	5.71^{b}	Amber / Paragon	8.9^{cde}
White lupin cv. Dieta	9.61^{def}	Amber / Logo	10.14^{def}
		Bora / Mammoth	7.63^{bcd}
Millet cv. Mammoth	2.50^{a}	Bora / Paragon	6.92^{bc}
Spring wheat cv. Paragon	10.10^{def}	Bora / Logo	10.09^{def}
Spring triticale cv.Logo	11.75^{fg}	Dieta / Mammoth	8.55^{cde}
		Dieta / Paragon	11.23^{efg}
		Dieta / Logo	13.43^{g}

LSD ($P < 0.05$) = 2.70
SED =1.34

Values within the table followed by the same letter superscript are not significantly different.

The dry matter yield of the forages is shown in Table 1. Mammoth millet established very slowly and yielded poorly as a monocrop. Bicrops of yellow and blue lupins with wheat and triticale appeared to yield better than lupins grown alone but less well than the respective cereal monocrops. Significant differences can be seen from Table 1. White lupins and white lupin combinations with spring wheat or triticale gave the best dry matter yields.

Table 2. *Crude protein (CP) modified acid detergent fibre (MADF) and estimated metabolisable energy (ME) content of spring sown lupins, cereals and lupin / cereal bicrops*

	CP g kgDM^{-1}	MADF g kgDM^{-1}	Estimated ME * MJ kgDM^{-1}
Yellow lupin cv. Amber	172.46	343.70	9.36
Blue lupin cv. Bora	202.39	301.18	10.17
White lupin cv. Dieta	172.72	277.43	10.62
Millet cv. Mammoth	90.12	277.40	10.62
Spring wheat cv. Paragon	83.19	263.83	10.87
Spring triticale cv.Logo	80.85	287.08	10.43
Amber / Mammoth	120.06	290.20	10.38
Amber / Paragon	125.25	281.78	10.53
Amber / Logo	130.65	298.50	10.22
Bora / Mammoth	185.85	286.33	10.45
Bora / Paragon	142.78	269.70	10.76
Bora / Logo	103.05	279.63	10.58
Dieta / Mammoth	155.30	339.25	9.45
Dieta / Paragon	152.25	274.83	10.67
Dieta / Logo	112.87	284.33	10.49
LSD (P<0.05)	0.37	0.13	
s.ed	0.19	0.06	

*AFRC (1993)

Crude protein and MAD fibre analysis results are shown in Table 2. ME was estimated from information contained in AFRC (1993) but in view of the lack of standards for this type of crop the figures should be treated with caution. Mono-crop lupins had the highest crude protein contents and the most successful bicrop combination was that of Dieta white lupins that achieved moderately good protein levels and a reasonably high ME value.

Discussion and Conclusions

Bi-cropping lupins with cereals was successful in an organic situation and gave worthwhile yields of forage. Yield improvements over mono-crops were small and not always significant but improvements in protein content were substantial and statistically significant. The combination of Dieta white lupin with Paragon spring wheat appeared to be the most successful interms of dry matter yield and crude protein content. Mammoth millet was not apparently successful in this situation but was seen to offer worthwhile competition with weeds in the under-storey of these organic crops. MAD fibre analysis and estimates of ME indicated a reasonably satisfactory outcome in terms of the energy value of the forage, although it is stressed that such estimates should be treated with caution in view of the lack of available standards for comparison. It is concluded that Dieta white lupins and spring wheat or spring triticale offer the best prospects for a viable wholecrop forage crop in an organic situation.

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