Effects of lucerne and medics on subsequent crops in the Victorian mallee

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ABSTRACT

Two experiments were established at Glenloth East and Walpeup in the Victorian Mallee to investigate effects of lucerne and annual medic based pastures on subsequent crops in semi-arid areas. At Walpeup lucerne pastures average annual production was 1880 kg DM/ha compared with 540 kg DM/ha for medic based pastures. At Glenloth the averages were 3860 kg DM/ha and 1240 kg DM/ha respectively. Above ground N fixed was estimated to be 81 kg/ha for lucerne and 13 kg/ha for medic at Glenloth, while at Walpeup estimates were 44 kg/ha and 10 kg/ha respectively. At Glenloth there was significantly greater soil nitrogen accumulation with lucerne based pasture than with annual medic pastures. This difference was associated with differences in tissue N concentration, biomass and N accumulation of following wheat crops. However crop yield responses were limited, presumably due to very dry seasonal conditions. At Walpeup no differences in soil N accumulation were apparent for different pasture types.

INTRODUCTION

The perceived benefits of lucerne on cropping enterprises include: reduced ground water recharge and reduced soil salinity, increased soil fertility through a longer more reliable pasture phase building nitrogen (N) and organic matter, increased grain yield and protein, decreased soil structure decline, reduced rate of surface soil acidification on some soils, increased control of herbicide resistant weeds in longer pasture phases, improved weed control, (eg skeleton weed, caltrop) and increased profitability of the grazing enterprise.

Community driven salinity management plans in Victoria have given a high priority to increasing the area of lucerne but there is a lack of sound scientific information on crop and soil advantages and disadvantages of lucerne in the low rainfall zone. A previous experiment at Walpeup (2) indicated improved winter herbage production and wheat yield (>40%) from grass cleaning medic pastures with selective grass herbicides. Questions relate to the magnitude of effects such as; N accumulation and N nutrition of subsequent crops, crop yield reductions from increased soil water utilisation by lucerne, effects on grain protein, crop disease implications and possible weed reductions brought about by the strong competitive nature of lucerne and the economic impact of lucerne in crop rotations.

The project aims were to evaluate the productivity of lucerne - based or annual medic - based pastures and their effects on crop yield, grain protein and soil characteristics.

METHOD

To investigate these issues two experiments were established in autumn 1995 in the low rainfall soils of NW Victoria. Experiments were conducted at Glenloth East (36?04'S,143?24'E), 25 km north of Charlton in Northern Victoria and on the Mallee Research Station at Walpeup (35?07'S,142?02'E) in the Victorian Mallee, 30 km west of Ouyen. Mean average rainfall at the Glenloth site is 395 mm with an April-October average of 264mm. The Glenloth topsoil was a clay loam, pH(H_20) 7.1, Olsen P 9 mg/kg. Mean average rainfall at Walpeup is 346 mm with an April-October average 229. The topsoil was a sandy loam, pH(H_20) 6.8, Olsen P 7 mg/kg.

At both sites two pasture types were sown: annual medic (Medicago truncatula cv. Paraggio, 10 kg/ha) and an annual medic – lucerne mix (Medicago truncatula cv. Paraggio, 10 kg/ha, Medicago sativa cv. Aurora, 2 kg/ha). Pasture management treatments were then imposed on the two pasture types: grass removal (grass cleaning) with chemical treatments (continuously grass cleaned each year v. grass

cleaned last year before crop) and two phosphorous treatments (-no P fertiliser -v. P fertiliser at 10kgP/ha annually as superphosphate). Both experiments were a 2*2*2 factorial design with 3 replications in randomised blocks. Each year an additional section of each plot was brought into the cropping phase. Lucerne was killed by cultivation in either January or February prior to cropping in May or June. Wheat was grown at both sites. Pastures and crops (PpCc) are referred by years of pasture (p) preceding years of crops (c). The headings in Table 2 detail the number of years of pasture (0–2), grown prior to each crop (1–3). Sheep rotationally grazed pastures at both sites.

RESULTS AND DISCUSSION

Pasture growth

Lucerne based pastures produced three times the growth of annual medic plots at both sites (Table 1). At Glenloth lucerne pastures averaged 3860 kg DM/ha compared to 1240 kg DM/ha for medic based pastures. At Walpeup the averages were 2050 kg DM/ha and 770 kg DM/ha respectively. Grass cleaning reduced winter - spring dry matter production by 0% to 20% at both sites over the 3 years, but had no effect on summer – autumn production, or legume productivity. Phosphorous treatments had no significant effect on pasture production.

Estimates of nitrogen fixed are derived from the total mass of legume produced (3). Total legume growth of pastures increased four fold as a result of lucerne at both sites (Table 1). At Glenloth lucerne pastures averaged 3230 kg/ha of legume compared to 520 kg/ha for medic based pastures. At Walpeup the averages were 1750 kg/ha and 420 kg/ha of legume DM respectively. Estimates of N fixed using the assumption of 25 kg N fixed per tonne of legume (3) were 81 kg/ha for lucerne and 13 kg/ha for medic at Glenloth, while at Walpeup estimates were 44 kg/ha and 10 kg/ha respectively. Lucerne was capable of reasonable production even in the very dry years of 1997 and 1998 (Table 4). At Walpeup in 1997 annual medic pastures produced 130 kg DM/ha with a growing season rainfall of 169 mm, while in 1996 the annuals produced 1200 kg DM/ha, a ten-fold difference. For lucerne, the production was 1200 kg DM/ha in 1997 while in 1996 2700 kg DM/ha, a two fold difference.

Table 1. Effects of pasture type on total pasture production and legume production at Glenloth and Walpeup in the seasons (Mar-Feb) 1996-97, 1997-98 and 1998-99 (kg DM/ha/annum). (* - P<0.001).**

		Glenloth			Walpeup		
Treatment		Medic	Lucerne	L.S.D.	Medic	Lucerne	L.S.D.
Total pasture production	1996-97	1280	4090	180 ***	1200	2710	370 ***
	1997-98	1690	4150	340 ***	130	1200	130 ***
	1998-99	750	3350	370 ***	990	2250	120 ***
Pasture Legume component	1996-97	450	3170	260 ***	850	2320	380 ***
	1997-98	930	3540	410 ***	30	1120	140 ***

1998-99	190	2970	370 ***	400	1820	160 ***

Crop and soil results

Below average April-October growing season rainfall in 1997 and 1998 limited yield potential to approximately one third to one half the long-term average estimated from the French-Schultz rainfall-yield relationship (1). Despite these severe rainfall constraints on crop (and pasture) yields, results demonstrated a strong cumulative effect of pasture duration and type at Glenloth, and a less pronounced effect of pasture duration at Walpeup. Crops and soil results from Walpeup were inconclusive due to very dry seasons.

Crop disease

There was no difference in wheat disease status following annual or lucerne pastures. The first crops after the pasture treatments had low levels of Takeall, Rhizoctonia and Cereal Cyst Nematode in both 1997 and 1998 at both sites. Pratylenchus was measured in 1998 only. There were low levels at both locations with no differences between treatments.

Soil available nitrogen (SAN)

At the time of sowing at Glenloth, SAN (nitrate and ammonium) for Crops 1, 4 and 6 (immediately following 0, 1 and 2 years of pasture, respectively) revealed an average annual increase of 16 kg SAN /ha/year in medic, and 41 kg SAN /ha/year for lucerne at Glenloth (Table 2). At Walpeup there were no significant effects of pasture type on SAN at the sowing (Table 2) and tillering (data not shown) stages except for the first crop in 1996, this may be due to the very dry seasons.

Table 2. Effects of Medic and Lucerne on soil available N (kg N/ha) to 0.66 m. measured at sowing at Glenloth and Walpeup. (ns - not significant, * - P<0.05, ** - P<0.01, * - P<0.001).**

Site	Crop	1	2	3	4	5	6
		P0C1-1996	P0C2-1997	P0C3-1998	P1C1-1997	P1C2-1998	P2C1-1998
Glenloth	Medic	29	na	na	44	na	62
	Lucerne	26	na	na	68	na	109
	LSD	4ns			21*		20**
Walpeup	Medic	71	32	81	38	109	119
	Lucerne	61	35	84	40	106	110
	LSD	7 **	8ns	13ns	12ns	24ns	28ns

Crop nitrogen uptake

Despite severe rainfall constraints on crop (and pasture) yields, SAN and crop nitrogen uptake results demonstrate a strong cumulative effect of pasture duration and type at Glenloth, and a less pronounced effect of pasture duration at Walpeup.

At Glenloth plant N uptake at anthesis (NUA) ranged from 17 kg N/ha (Crop 1) to 75 kg N/ha in lucerne treatments of Crops 5 and 6 (Table 3). In crops 4, 5 and 6 crop nitrogen uptake was 20 kg/ha greater where the crop followed lucerne than where it followed the medic based pasture. NUA was strongly related to soil available N to 0.66 m (SAN) measured at tillering (NUA = -9 (se4.43) + 1.83 SAN_{til}; n = 6; R^2 = 0.92). The increase in NUA effected by lucerne in Crops 4, 5 and 6 was partly due to increased plant biomass in Crops 4 and 6 (P<0.01 in both cases), and to increased plant N concentration in plant tissues (P = 0.06, P< 0.01 and P < 0.01, in Crops 4, 5 and 6, respectively.).

At Walpeup, NUA varied from a minimum of 19 kg N/ha in medic treatments of Crop 2 to a maximum of 62 kg N/ha (medic, Crop 6, Table 3). Significant differences favoured lucerne in Crop 2 (P < 0.01) and medic (Crop 6; P < 0.05), associated with greater crop biomass in Crop 2 (P < 0.01) and a combination of greater size (P < 0.05) and increased N concentration (P < 0.05) in Crop 6. While NUA was strongly related to SAN at tillering at Glenloth, NUA at Walpeup was related to SAN at sowing (NUA = 9.11 + 0.40 SAN_{sow}; n = 6; R^2 = 0.84).

Table 3. Effects of medic and lucerne on crop N uptake (kg N/ha) measured at anthesis in Crops 1–6 at Glenloth and Walpeup.

Site	Crop	1	2	3	4	5	6
		P0C1-1996	P0C2-1997	P0C3-1998	P1C1-1997	P1C2-1998	P2C1-1998
Glenloth	Medic	17	17	41	18	56	50
	Lucerne	18	15	43	33	73	79
	LSD	4.3 ns	6.8 ns	5.5 ns	9.5**	12.6*	10.3**
Walpeup	Medic	26	19	41	32	53	62
	Lucerne	25	26	40	31	55	52
	LSD	6.8ns	3.2**	5.3ns	3.7ns	5.3ns	7.8*

Grain yield

Table 4 shows that below-average April-October growing season rainfall in 1997 and 1998 limited yield potential to approximately 1100 kg/ha and 1550 kg/ha respectively (Table 4). This is one-third to one-half their long-term average French-Schultz relationship (1). In 1996, average growing season rainfall at Walpeup suggested a yield potential of approximately 2100 kg/ha, whereas the yield potential was 4300 kg/ha with above average rainfall at Glenloth. Crop yields of first crops after 0, 1 and 2 years of the pasture alternatives (crops 1, 4 and 6) averaged 18%, 69% and 27% of their French – Schultz potential yield at Glenloth and 54%, 47% and 52% of their potential yield at Walpeup.

At Glenloth crop yield was constrained by soil N infertility and waterlogging in July in Crop 1, resulting in a mean yield of approx. 800 kg/ha. Improved soil N status coincided with low yield potentials set by rainfall in Crops 2 – 6: mean yield of Crops 3 and 5, grown in 1998, was 500 and 390 kg/ha, respectively. (Table 5). There were no differences in crop yield between pasture treatments except for the first crop after lucerne in 1998 when lucerne significantly decreased yield of Crop 6 from 850 kg/ha to 550 kg/ha as a result of haying off despite increased nitrogen uptake at anthesis. Soil structural problems of surface sealing and hard setting also presumably contributed to low yields at Glenloth.

At Walpeup crop yield ranged from 600 kg/ha in Crops 2 and 4 to 1200 kg/ha in crops 1,3, 5 and 6 (Table 5). Crops after lucerne (crops 4, 5 and 6) averaged about 10% less yield than crops after medic based pastures ($P \leq 0.01$ in each case). At Walpeup the sandy loam soil with low water storage capacity presumably contributed to the low yields.

Table 4. Growing season rainfall (mm) with the French-Schultz potential wheat yield (kg/ha) in brackets appropriate to crops grown at Glenloth and Walpeup.

Site	1996	1997	1998	Long term mean
Glenloth	324 (4280)	163 (1060)	187 (1540)	264 (3080)
Walpeup	216 (2120)	169 (1180)	190 (1600)	229 (2380)

Table 5. Effects of Medic and Lucerne on yield (kg/ha) of Crops 1 - 6 at Glenloth and Walpeup.

Site	Crop	1	2	3	4	5	6
		P0C1-1996	P0C2-1997	P0C3-1998	P1C1-1997	P1C2-1998	P2C1-1998
Glenloth	Medic	874	798	522	749	411	846
	Lucerne	769	814	490	703	365	543
	LSD	228ns	110ns	203ns	175ns	104ns	142**
Walpeup	Medic	1205	774	1285	640	1358	1286
	Lucerne	1103	721	1245	487	1271	1164
	LSD	243ns	114ns	66ns	115*	60**	75**

Grain protein

At Glenloth grain protein (Leco method) content ranged from 6.6% (Crop 2) to maxima of 12.2 % and 13.7 % in lucerne treatments of Crops 5 and 6 (Table 6). All crops after lucerne (crops 4, 5 & 6) had an average 3.1% protein increase compared to medic. At Walpeup grain protein increased from 7% to 10 %, in Crops 1 – 4, to a mean of 12 % in Crops 5 and 6 (Table 6). Lucerne significantly increased grain protein in Crop 5 (the second crop after 1 year of lucerne in 1998).

Table 6. Effects of Medic and Lucerne on grain protein content (%) of Crops 1 - 6 at Glenloth.

Site	Crop	1	2	3	4	5	6
		P0C1-1996	P0C2-1997	P0C3-1998	P1C1-1997	P1C2-1998	P2C1-1998
Glenloth	Medic	7.8	6.6	8.3	7.4	9.5	10.3
	Lucerne	8.0	6.9	8.9	10.7	12.2	13.7
	LSD	0.4ns	0.6ns	0.8ns	3.0*	1.9**	2.0**
Walpeup	Medic	9.3	7.0	9.7	7.5	11.4	12.8
	Lucerne	9.2	8.8	9.6	8.7	12.4	12.7
	LSD	0.57ns	1.67*	0.89ns	1.27ns	0.99**	0.95ns

Soil water

There were no significant differences in crop root zone soil water at sowing, tillering, anthesis or harvest attributed solely to pasture type or management at either site. Stored soil moisture made little contribution to growth in the very dry seasons of 1997 and 1998. The yield reductions due to lucerne at both sites could be related to haying off in very dry seasons.

ACKNOWLEDGMENTS

The work was funded by the Grains Research and Development Corporation, (project UA301) and the Victorian Department of Natural Resources and Environment.

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