Pasture cropping in the Central West and Lachlan CMAs

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Abstract: *An on-farm survey of pasture cropping systems was undertaken in 2008, comparing pasture cropping to non-cropped pasture within the Central West and Lachlan CMAs. Pasture types ranged from introduced to native pastures. Grain yields were less than those possible from conventional crops, with soil nitrogen a major limiting factor. Paddocks with low soil N would require significant N inputs to obtain successful forage or cereal production. Overall forage production, litter and ground cover were unaffected by pasture cropping systems.*

Introduction

Pasture Cropping is an innovative farming system where winter cereal crops are sown directly into summer growing native pastures to utilise a difference in summer–winter growth phases. Previous Pasture Cropping research has been located at Gulgong (Bruce *et al* 2005) and Wellington (Millar & Badgery 2009). These locations were thought to be well suited to pasture cropping as the non-seasonal rainfall provides sufficient summer rainfall for the C_4 summer growing native pastures, and sufficient winter rainfall for a winter cereal. While there has been some research work undertaken at drier locations, e.g. Trangie and Condobolin (Millar and Badgery 2010), results have been variable. However, Pasture Cropping and no kill cropping (Badgery and Millar 2009) have now been adopted by farmers outside the Gulgong/Wellington area, with variable results. To provide some information into the area of suitability of Pasture Cropping systems, a survey was conducted in 2008 on properties that were adopting Pasture Cropping within the Central West and Lachlan Catchment Management Authorities.

Methods

Eight locations were selected involving 11 sites (Table 1). Within a pasture paddock, two 50m by 18m plots were set up – one was left as undisturbed pasture (PA), while the other had a form of Pasture Cropping (PC).

Plant composition, litter, biomass and ground cover were determined using Botanal assessments (Tothill *et al* 1992) from 20 quadrats per plot. Assessments were done pre-sowing and at peak biomass times (prior to crop harvest 2008). Crop calibration cuts were taken at maturity to derive a Harvest Index for each crop. This enabled grain yield to be calculated from estimated total biomass. Because of the wide range of species recorded, standing composition was split into crop or pasture, with pasture further split into perennial (grasses and legumes), annual grasses and other.

Soil samples were collected in autumn 2008 (pre-sowing) at 0–5, 5–10, 10–20, 20–30, 30–40 cm depths for soil nitrogen (SN) analysis.

Results

Site descriptions and rainfall over survey period

Of the eleven sites (Table 1), three were located on sown or introduced perennial pasture species (S), while the remainder were on native perennial pastures (N). The introduced pasture species were all temperate C_3 species, while the dominant native pastures were all C_4 species. Pasture Cropping was undertaken on all sites except the sites located at Mandurama (S1 and N1). At these two sites, No Kill Cropping was undertaken with oats sown dry in February. Wheat was the dominant cereal sown (7 sites), while oats (3 sites) and barley (1 site) were also sown. At one site, S3, sowing error meant that no plot of undisturbed pasture area was left.

Table 1. Site code, location, major pasture species, sown crop, annual rainfall (mean and 2008), May to October rainfall (mean and 2008), and soil nitrate (mg/kg) down the soil profile for each site in autumn 2008. Nitrogen required derived from that by Holford and Doyle (1992).

Site Code	Location	Major pasture species	Sown Crop	Annual rain (mm)		May to October (mm)		Soil nitrate (mg/kg)					Nitrogen required (kg/ha)
				Mean	2008	Mean	2008	0–5 cm	5–10 cm	10–20 cm	20–30 cm	30–40 cm	
S1	Mandurama	*Lolium perenne*	Oats	922	897	527	416	47.0	26.0	18.0	12.0	5.2	10
S2	Cumnock	*Dactylis glomerata*	Oats	650	700	321	333	17.1	6.6	7.3	9.0	7.5	70
S3	Gollan	*Medicago sativa*	Wheat	612	726	270	295	10.0	5.8	2.9	1.0	0.8	120
N1	Mandurama	*Themada australis*	Oats	921	897	527	416	5.4	3.2	0.9	0.2	0.3	120+
N2	Wellington	*Chloris truncata*	Wheat	615	661	297	260	31.0	10.7	5.9	2.2	0.9	70
N3	Wellington	*Bothriochloa macra*	Wheat	615	661	297	260	22.5	9.2	4.4	1.5	1.1	80
N4	Trangie	*Enteropogon ramosus*	Wheat	493	512	217	190	20.0	20.5	11.5	3.4	3.9	55
N5	Trangie	*Chloris truncata*	Wheat	493	512	217	190	11.2	14.0	15.5	4.6	5.7	65
N6	Wirrinyah	*Chloris truncata*	Barley	480	369	239	144	16.5	16.0	16.0	8.7	3.7	65
N7	Condobolin	*Enteropogon ramosus*	Wheat	455	447	219	133	8.1	14.6	11.7	4.6	10.5	70
N8	Warren	*Chloris truncata*	Wheat	437	415	199	142	6.2	1.7	0.7	0.6	1.1	120+

Most survey sites showed a typical non-seasonal rainfall pattern, where mean monthly rainfall was similar throughout the year. In 2008, all sites had close to or exceeded annual rainfall, except N6 which received 75% of its average rainfall. Most sites experienced greater than 85% of their May to October rainfall, except N6 and N7 (60%), N8 (70%) and S1 and N1 (80%).

Soil nitrogen

Soil nitrate was quite variable amongst the sites, with the two Mandurama sites prominent, as S1 had the greatest amount of soil nitrate and N1 the least (Table 2). Nitrate was greatest in the top 5 cm of soil, except for N5 and N7 which had maximum nitrate in the 5–10 cm layer, and N4 and N6 which had similar nitrate levels in the 0–5 and 5–10 cm layers. Most of the sites showed a 50% reduction in nitrate from 5–10 cm to 10–20 cm below the soil surface. N5, N6 and N7 showed a 50% reduction in nitrate from 10–20 cm to 20–30 cm below the soil surface. N7 had a 50% increase in nitrate in the 30–40 cm layer. There was no overall difference between the PA and PC treatments. Following on from Holford & Doyle (1992), the amount of N required for a wheat crop was determined from the nitrate levels recorded. This indicated that N fertiliser was required in most instances, with over 120 kg N/ha required for successful cereal production at N1 and N8. This contrasts with the low amount of N actually applied at sowing (less than 10kg N/ha), indicating that the full potential crop yield was unlikely to be obtained from these paddocks.

Plant and crop production

Assessments of pre-treatment composition, biomass, litter and groundcover in autumn 2008 indicated a wide range between sites, with little difference between treatments at each site. Unfortunately, initial assessments at the two no kill cropping sites (S1 and N1) were made after sowing. While N1 was sown with a disc seeder, for S1 a tyned implement was used which disturbed the soil surface, greatly affecting pasture condition as total biomass and ground cover were reduced by half in the cropped plot.

Table 2 presents the data collected for composition, biomass, litter, estimated grain yield and ground cover assessed prior to grain harvest. There were no consistent differences between the treatments over all sites for standing, annual grass, green and litter biomass, or for perennial, annual grass and green percentages of standing biomass. Biomass measurements prior to harvest showed no overall difference in total biomass between the pasture and cropped treatments (range of 1.2 to 6.4 t/ha, mean of 3.3 t/ha), but there was significantly ($P<0.05$) more pasture and ground cover on the non-cropped treatments compared to those treatments cropped (2.2 v 1.5 t /ha of pasture, 72 v 66% ground cover). Ground cover was greatly reduced by PC at only one site N4 (reduced from 69 to 49%). For the other sites, there was on average less than 5% reduction in ground cover due to PC.

Estimated grain yields from the plots were generally poor (Table 2). Only 2 sites yielded over 1 t/ha (1.68 t/ha of oats at S2 and 1.23 t/ha of barley at N6) with the other sites averaging 0.3 t/ha. These yields compare poorly to potential yields as determined by Sadras and Angus (2006) based on growing season rainfall, except for N6. The two No Kill Cropping sites at Mandurama (S1 and N1) produced very little crop biomass which resulted in little grain. Five sites had insufficient grain to harvest (S1, N1, N4, N5 and N7) while the other sites averaged less than 1 t/ha.

Discussion

All of the crop yields obtained through pasture cropping in this survey were well below those from conventional crops. This is similar to the results from a degraded lucerne paddock at Wellington in 2008, where conventional cropping out-yielded perennial intercropping by over 40%. With above average summer rainfall and below average autumn and winter rainfalls, a conventional fallow would have provided extra soil moisture for cereal growth. The above average spring rainfall was predominately in November, and caused more harm than good as it had little effect on crop yields but delayed harvest in many instances.

Table 2. Standing (crop, pasture, perennial and green) and litter biomass (kg/ha), estimated grain yield (t/ha), perennial and green % of standing biomass and ground cover in late spring 2008 for pasture (PA) and pasture cropped (PC) plots. Potential yields are derived from growing season rainfall (Sadras & Angus 2006). Site codes as per Table 1.

Site code	Treatment	Biomass (kg/ha)							Grain Yield (t/ha)	PotentialYield (t/ha)	Perennial (%)	Green (%)	Ground Cover (%)
		Standing	Crop	Pasture	Perennial	Annual grass	Green	Litter					
S1	PA	3075		3075	1568	447	1638	550			51	53	100
	PC	2525	88	2437	700	653	1713	613	0.009	4.2	28	68	98
S2	PA	4236		4236	912	1677	1220	1120			22	29	75
	PC	6106	4202	1903	399	1145	259	1100	1.681	3.3	7	4	71
S3	PA	n/a	n/a	n/a	n/a	n/a	n/a	n/a			n/a	n/a	n/a
	PC	2863	1133	1730	771	811	669	935	0.555	2.7	27	23	40
N1	PA	1698		1698	730	901	895	628			43	53	91
	PC	1455	18	1437	1127	187	975	708	0.002	4.2	77	67	96
N2	PA	4114		4114	3139	493	1617	1169			76	39	97
	PC	3881	2365	1515	1067	106	587	1500	0.852	2.6	27	15	87
N3	PA	4027		4027	3300	566	1173	2108			82	29	93
	PC	4791	1764	3027	2813	179	1027	1928	0.759	2.6	59	21	91
N4	PA	763		763	87	154	437	731			11	57	69
	PC	682	24	658	183	150	378	676	0.004	1.9	27	55	49
N5	PA	1212		1212	303	96	682	649			25	56	64
	PC	1445	198	1248	99	83	807	565	0.034	1.9	7	56	63
N6	PA	664		664	314	276	13	223			47	2	45
	PC	3184	2624	560	250	233	12	198	1.233	1.4	8	0	37
N7	PA	1023		1023	913	19	296	240			89	29	31
	PC	1072	245	827	815	0	190	194	0.090	1.3	76	18	26
N8	PA	1111		1111	1057	21	146	85			95	13	54
	PC	2662	1523	1139	1101	4	53	71	0.655	1.4	41	2	44

On sites with vigorous native pastures utilising N over summer (N1, N2, N3, and N8), or a history of low N input (S3), soil N below 10cm was limiting, with S3 requiring 120kg N/ha for successful cereal production (Holford & Doyle, 1992). This compares to the Redgrass trial paddock at Wellington where N was limiting grain production, 100 kg N/ha would be required to obtain potential cereal yield (Millar & Badgery 2009). The notion that Pasture Cropping is a minimal input system is very dependant on paddock condition. Paddocks with low N will require significant N inputs to obtain successful forage or cereal production levels. To offset this utilisation of N over summer in low input systems, legumes need to be incorporated into the pasture system. Kemp *et al* (1994) reported that maintaining low biomass over spring encourages perennial and annual legumes. However, this would not happen in a continuous Pasture Cropping where the bulk of biomass production reaches a peak in late spring with the growth of the cereal.

Pasture production was suppressed by the cropping activity, but this was often compensated by the forage production available from the sown cereal. Ground cover and litter were not greatly affected by pasture cropping systems in most instances. Initially for ground cover, there was an effect of sowing technique, where disc systems showed minimal soil disturbance compared to tyned systems (eg N1 – disc and S1– tyned). However, by harvest time there was little difference between the cropped and non-cropped treatments.

While no data was collected on the costs of implementing the pasture cropping systems, in this survey there was very little extra forage or grain production to warrant the economic implementation of these systems, especially the two No Kill Cropping plots at Mandurama.

Acknowledgements

The author would like to thank D.I. Pickering for his assistance in this work. Pasture cropping research was funded by the Central West/ Lachlan Grain & Graze program, and was conducted by Industry and Investment NSW.

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