Cereal based forage crops for hay and silage production

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Abstract: Cereal and cereal/vetch forage crops were grown at Culcairn, New South Wales (NSW) in 2009 and Temora, NSW in 2010 to evaluate yield and quality when harvested at the boot, anthesis (flowering), milk and soft/mid dough stage of cereal development. Annual rainfall at the sites was 377 mm in 2009 and 736 mm in 2010. Average yield (tonnes (t) dry matter (DM)/ha), Metabolisable Energy (MJ/kg DM) and crude protein (%) content were 6.61, 10.45, 12.0 and 21.08, 9.41, 14.76 in 2009 and 2010, respectively. Metabolisable Energy content of crops was higher in 2009 compared with 2010 and declined more slowly with maturity. Cereal/vetch mixtures had significantly (P <0.001) higher crude protein content than cereal only crops which was reflected in a positive improvement in predicted liveweight gain for weaner sheep and cattle.

Key words: cereal, vetch, forage, maturity, metabolisable energy, protein content, yield

Introduction

Production of beef and sheep meat is reliant on the supply of adequate nutrition for both breeding and finishing animals. In Australia, livestock production from grazing is restricted by seasonality of pasture growth and quality. Across southern Australia pasture growth occurs predominantly in spring with autumn production significant in some areas and in some years. In winter, pasture quality is usually high but availability is low whereas in summer there is residual dry standing pasture available but forage quality is only moderate; later in the season there is a further decline in quality combined with a decline in availability. Producers feed grazing livestock supplements of hay, silage, grain and/or meals to provide the additional energy (and crude protein, CP) required for maintenance and production.

Many areas of southern Australia are very suitable for growing cereal and cereal/legume forage crops which can be conserved for either hay or silage to supplement grazing livestock at a later date. Cereals are high yielding and of moderate to high quality depending on maturity at harvest. Growing cereals with a legume is a management option to ensure adequate crop protein content and ameliorate any decline in digestibility that occurs with increasing maturity at harvest. However including a legume can reduce yield. This paper will present results from two experiments that were conducted across southern New South Wales (NSW) at Culcairn in 2009 and Temora in 2010 to evaluate the yield and quality of cereal and cereal/vetch forage crops grown for conservation as either hay or silage.

Materials and methods

Seven cereal varieties were selected to provide a cross section of types grown in southern NSW and were either grown as a monoculture or in a mixture with popany vetch (*Vicia benghalensis*). The cereal varieties were Tobruk triticale, two wheats Strezlecki (grain only) and Wedgetail (dual purpose), two barleys varieties Gairdner (malting) and Urambie (dual purpose), and two oats varieties Echidna (grain) and Mannus (dual purpose). The crops were sown at 70 kg/ha cereal or 15 kg/ha cereal plus 60 kg/ha vetch in the mixtures, at 15 cm row spacing. MAP fertiliser at the rate of 105 kg/ha was applied at sowing. There were three replicates of each treatment.

Samples from each plot were cut, approximately 5 cm above ground, by hand at the boot, anthesis (flowering), milk and soft/mid dough stage of cereal grain development. None of the plots were taken to maturity for cereal grain harvests.

A subsample was dried at 80°C for 24 h to determine dry matter (DM) content. Botanical composition was determined for the vetch and cereal mixes. Metabolisable Energy (ME) content (MJ/kg DM) was determined by NIR.

Growth rates and intake for 300 kg British breed steers and 30 kg crossbred wethers were predicted using Grazfeed (version 5) based on estimated feed quality (ME and CP) data and assuming *ad libitum* intake of the forage as the sole diet. Expected value ($) of livestock production of these crops was calculated assuming that only 50% of the forage was conserved and further losses/wastage reduced production by 20%.

Results and discussion

Seasonal conditions varied markedly between 2009 and 2010. At Culcairn in 2009 the total annual rainfall at was 377 mm which was only 64.4% of the long-term average (586 mm) whilst in 2010 Temora received 736 mm, which was 40.5% above average (524 mm). A number of the later maturing plots from both experiments were not harvested; in 2009 the continuing drought led to the early senescence of a number of plots in each experiment, whereas in 2010 the wet conditions combined with high yields caused lodging and disease.

Yield

At Culcairn in 2009 the dry conditions limited yield which averaged 6.59 tonnes (t) DM/ha across all crops and harvests. The final harvest of the triticale/vetch and wheat/vetch plots was abandoned because the crops, especially the vetch component, had senesced. Yield differed (P <0.001) among cereal varieties and increased (P <0.001) with harvest with average yields of 5.54, 6.72, 7.04 and 7.40 t DM/ha at the boot, anthesis, milk and dough stage harvests, respectively. When averaged across all cereal varieties and harvests there was no difference in yield between cereal only and cereal/vetch crops, however the effect of vetch inclusion did vary (P = 0.002) with cereal variety (Figure 1). When averaged across harvests the inclusion of vetch increased yield for Strzelecki, but reduced yield on Tobruk and Wedgetail.

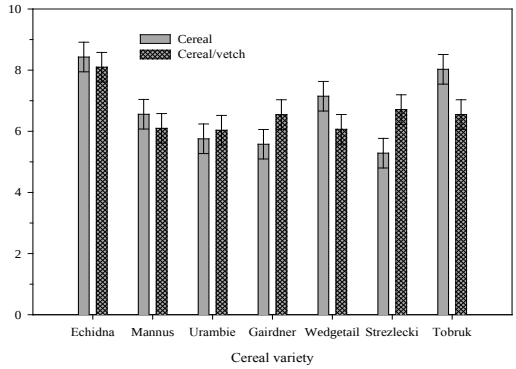

Figure 1. Effect of cereal variety and vetch inclusion on yield (t DM/ha) of cereal and cereal/vetch crops grown at Culcairn, NSW in 2009. Mean across all harvests. Note: yield estimates for Wedgetail and Strzelecki include predicted values for the final harvest of Wedgetail/vetch and Strzelecki/vetch crops. Only one plot of Tobruk/vetch was harvested at the dough stage.

Yield of both the cereal (P <0.001) and vetch (P = 0.003) component of the cereal/vetch crops was affected by cereal variety and yield of vetch increased (P = 0.012) with harvest whereas that of cereal did not (Figure 2). When compared

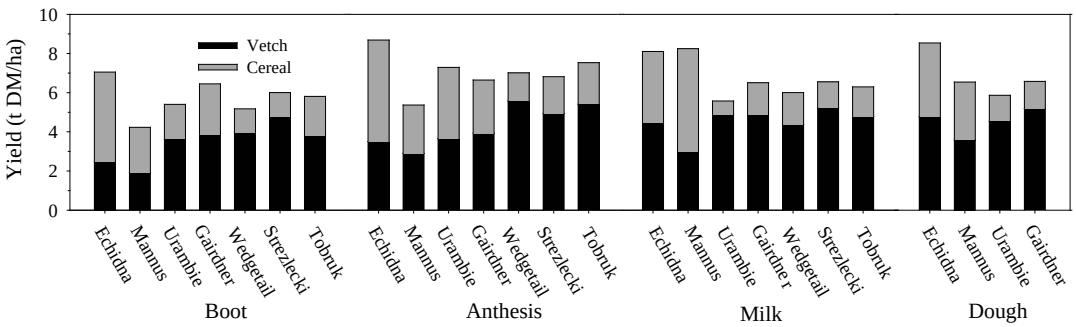

Figure 2. Effect of cereal maturity at harvest on the yield of the cereal and vetch components of cereal/vetch crops grown at Culcairn, NSW in 2009.

with the other cereal varieties Mannus had the lowest vetch yield at all harvests. Echidna had the second lowest vetch yield at the boot harvest and the highest cereal yield at all harvests, except milk stage when Mannus had the highest cereal yield.

Growing conditions at Temora in 2010 were markedly different and yield was not limited by moisture content. This was reflected in substantially higher yields, which averaged 21.1 t DM/ha. As was the case in 2009 yield varied with cereal variety (P <0.001) and increased (P <0.001) with harvest. In contrast to 2009 however yields were lower on plots containing vetch. There were also significant interactions between cereal variety, vetch treatment and harvest at all levels (Table 1).

Lodging of crops containing vetch was significant at later harvests though the degree of lodging varied. Because forage below the 5 cm cutting height was not harvested the yields in this experiment would have more closely reflected yields achieved when mowing for hay or silage rather than the amount of forage grown. The lower yields on cereal/vetch crops are therefore at least partly due to this lodging rather than differences in productivity between the two components. The biggest effect was on the Gairdner/vetch plots where yield actually declined between the milk and dough stage harvests. The wheat and triticale crops, which were later maturing and therefore harvested later, actually lodged to such an extent that the final harvests of these crops had to be abandoned.

Table 1. Effect of cereal variety, vetch inclusion and harvest on total yield (t DM/ha) of cereal/vetch crops grown at Temora, NSW in 2010.

Cereal species	Cereal variety	Vetch treatment	Harvest			
			Boot	Anthesis	Milk	Dough
Oats	Echidna	cereal/vetch	17.22	22.97	28.92	29.57
		cereal only	17.57	28.02	25.94	27.28
	Mannus	cereal/vetch	15.04	25.79	17.81	23.21
		cereal only	20.62	19.70	21.57	28.27
Barley	Urambie	cereal/vetch	10.20	12.27	19.58	17.31
		cereal only	10.13	16.32	20.10	25.84
	Gairdner	cereal/vetch	14.86	14.17	25.07	14.47
		cereal only	19.41	16.37	18.09	31.48
Wheat	Wedgetail	cereal/vetch	14.47	16.58	14.04	*
		cereal only	13.60	21.10	24.85	28.74
	Strzelecki	cereal/vetch	16.13	16.20	14.65	*
		cereal only	15.12	15.43	22.04	27.95
Triticale	Tobruk	cereal/vetch	16.56	17.58	17.11	*
		cereal only	15.97	21.40	30.72	37.719

l.s.d. P = 0.05, 5.82; *Only the plot in replicate one was harvested.

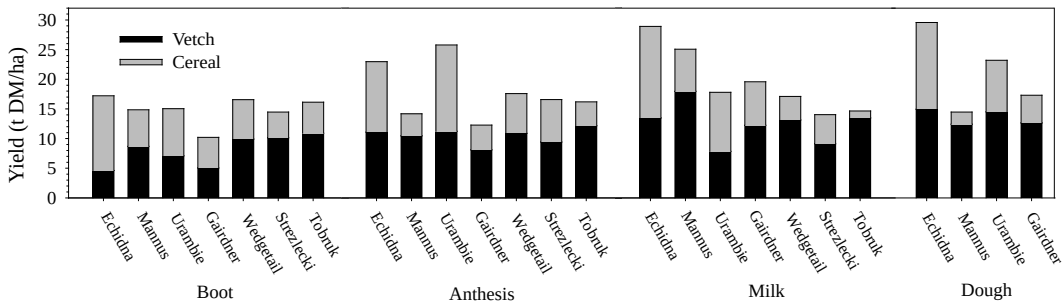

Figure 3. Effect of cereal maturity at harvest on the yield of the cereal and vetch components of cereal/vetch crops grown at Temora, NSW in 2010 at different harvests.

In the mixture, vetch yield increased with harvest, but not cereal variety whereas cereal yield varied (P <0.001) with cereal variety, but not harvest. Cereal and vetch yield for the mixtures at all harvests are presented in Figure 3.

Metabolisable energy content

The ME content of the crops harvested at Culcairn in 2009 was high (average 10.45 MJ/kg DM) and at the boot stage all combinations except Strzelecki/vetch exceeded ME 10.5 with four crops exceeding ME 11. There were ME differences (P <0.001) among cereal varieties and ME declined (P <0.001) with maturity, though it still remained high. There was no difference in ME between cereal and cereal vetch crops. Average ME was 10.5, 10.5, 10.8, 10.7, 10.5, 10.3 and 10.0 for plots containing Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki, Tobruk, respectively and 10.9, 10.4, 10.3 and 10.4 for harvests 1, 2, 3 and 4, respectively. All interactions were significant; variety and vetch (P <0.0018), variety and harvest (P <0.001, l.s.d. = 0.283), vetch and harvest (P <0.001, l.s.d. = 0.152) and variety, vetch and harvest (P <0.001).

Average ME content (9.41) of crops at Temora in 2010 was lower than that observed in 2009, varied with cereal variety (P <0.001), declined with harvest and was lower for cereal only plots. In this experiment, average ME was 9.15, 9.39, 9.89, 9.64, 9.11, 9.41 and 9.38 for plots containing Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki and Tobruk, respectively and 10.0, 9.52, 9.31 and 8.69 for harvests 1, 2, 3 and 4, respectively As in 2009 there was an interaction between variety and vetch (P <0.001), variety and harvest (P = 0.005), vetch and harvest (P = 0.002) and variety, vetch and harvest (P = 0.024). Predicted means from 2009 and 2010 for all treatments at all harvests are presented in Table 2.

Crude protein content

Average CP content of the 2009 crops was 12.0%. Crude protein declined (P <0.001) with maturity, varied (P <0.001) with cereal variety and was higher (P <0.001) for cereal/vetch compared with cereal only crops. Average CP was 14.30, 11.84, 10.88 and 9.86% for harvests 1, 2, 3 and 4 and 10.31, 11.37, 12.98, 12.44, 11.09, 12.90 and 12.97% for the Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki and Tobruk treatments, respectively. Including vetch increased average CP from 6.26 to 17.70%. In 2010, the average CP of the Temora crops was higher at 14.76% and, as was the case in 2009 declined (P <0.001) with maturity, varied (P <0.001) with cereal variety and was higher

Table 2. Effect of cereal variety, vetch inclusion and harvest on metabolisable energy content (MJ/kg DM) of cereal/vetch crops grown at Culcairn, NSW in 2009 and Temora, NSW in 2010.

Cereal species	Cereal variety	Vetch	Harvest stage							
			Culcairn 2009				Temora 2010			
			Boot	Anthesis	Milk	Dough	Boot	Anthesis	Milk	Dough
Oats	Echidna	vetch +	10.5	10.4	10.3	10.2	10.0	9.6	9.6	8.8
		vetch –	11.0	10.7	10.6	10.3	9.3	9.0	8.9	8.0
	Mannus	vetch +	11.4	10.4	10.3	10.1	10.6	9.8	9.6	9.1
		vetch –	11.5	9.8	9.7	10.3	10.4	9.3	8.8	7.5
Barley	Urambie	vetch +	10.6	10.6	10.5	10.7	10.3	10.2	10.1	9.7
		vetch –	11.1	10.8	10.8	11.1	10.4	9.8	9.5	9.3
	Gairdner	vetch +	10.5	10.6	10.5	10.7	10.5	10.2	10.3	9.6
		vetch –	11.1	10.5	10.4	11.3	9.7	9.1	8.8	8.3
Wheat	Wedgetail	vetch +	10.7	10.8	10.0	–	9.9	9.8	9.1	–
		vetch –	10.9	10.8	10.4	10.1	9.4	8.5	8.7	8.3
	Strzelecki	vetch +	10.5	10.4	10.7	10.4 *	10.4	10.0	10.2	–
		vetch –	10.9	10.3	9.5	10.3	9.3	9.0	8.5	8.4
Triticale	Tobruk	vetch +	10.6	10.5	10.6	–	10.5	10.3	9.7	–
		vetch –	10.5	9.4	9.3	9.1	9.6	8.3	8.9	8.4

l.s.d. P = 0.05, 0.39 (2009); l.s.d. P = 0.05, 0.54 (2010). *Only the plot in replicate one was harvested.

(P <0.001) for cereal/vetch compared to cereal only crops. For the 2010 crops, average CP was 18.08, 16.39, 13.91 and 10.10% for harvests 1, 2, 3 and 4 and 12.44, 13.77, 16.23, 18.36, 14.66, 12.52 and 13.82% for the Echidna, Mannus, Urambie, Gairdner, Wedgetail, Strzelecki and Tobruk treatments, respectively. The effect of including vetch on CP content of cereal and cereal/vetch crops is shown in Figure 4 (2009) and 5 (2010).

Predicted livestock production

Predicted liveweight gain (or loss) for both species was demonstrably lower on the cereal only crops compared to the cereal/vetch crops (Figure 6). The ME content of the cereal only and cereal/vetch crops in 2009 and the earlier harvests in 2010 was adequate to meet requirements for animal growth, however without vetch the CP content of the cereal only crops was inadequate for young, growing livestock. Steers on later harvest cereal only crops, in both 2009 and 2010, were predicted to lose weight because of this. Even the lowest ME content cereal crop, Mannus at the dough stage in 2010 (ME 7.5), should have been adequate for maintenance, but steers were predicted to lose 0.17 kg/day because of the low CP. The lowest predicted production from wethers was maintenance.

Based on predicted liveweight gain, intake and assuming a livestock price of $2.15/kg for steers and $2.60/kg liveweight for wethers estimated value of livestock income from utilising these crops is shown in Figure 7. In both 2009 and 2010, the predicted value of additional livestock production/ha was greater for wethers compared with steers. The predicted returns were higher in 2010 compared with 2009 which was a reflection of significantly higher yields. Where there were only minor increases in yield with maturity, as in 2009, animal production/ha and the value of product/ha was dictated by changes in forage quality. In 2010, animal production/ha varied with individual crops and was dependent on

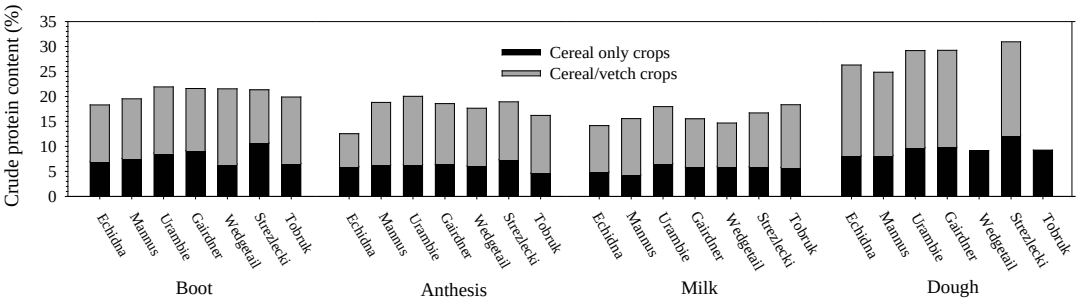

Figure 4. Effect of cereal maturity at harvest on the crude protein (%) content of cereal and cereal/vetch crops grown at Culcairn, NSW in 2009. Note: only one Strzelecki/vetch plot and no Wedgetail/vetch and Strzelecki/vetch plots were harvested at the dough stage.

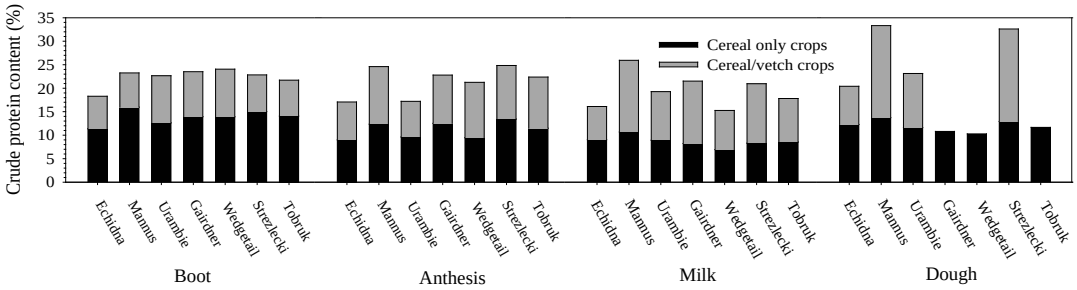

Figure 5. Effect of cereal maturity at harvest on the crude protein (%) content of cereal and cereal/vetch crops grown at Temora, NSW in 2010.

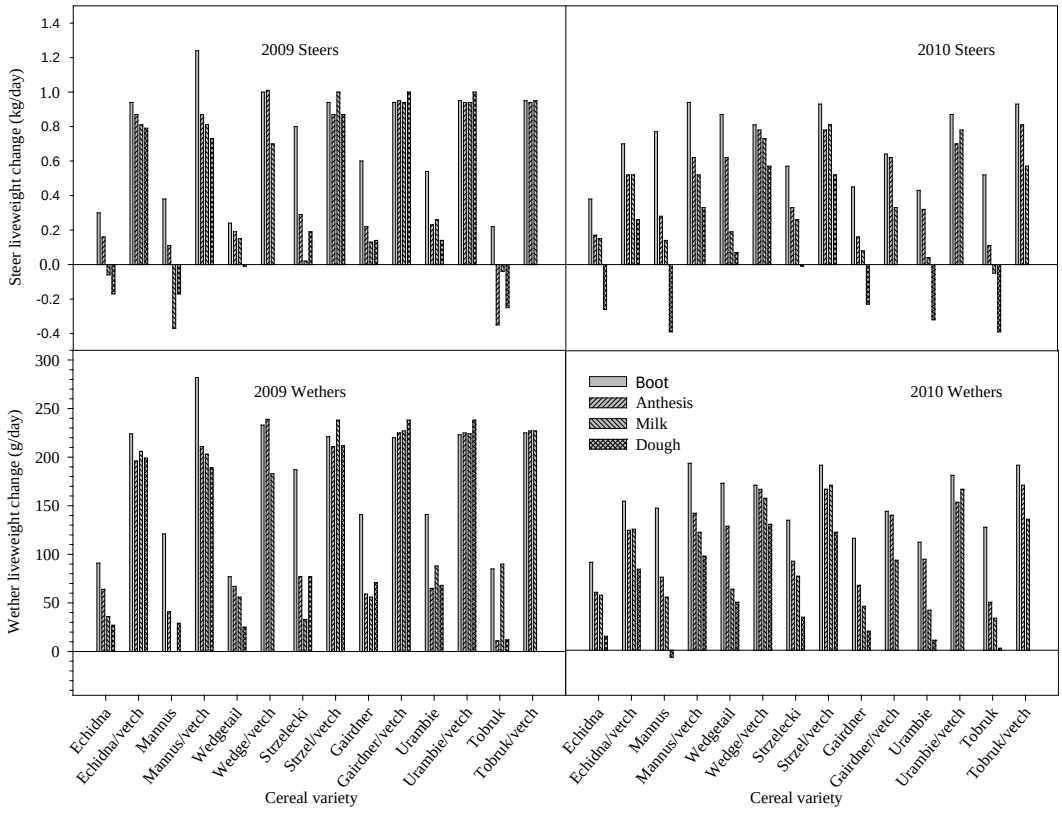

Figure 6. Effect of cereal variety, vetch and harvest on predicted daily liveweight change of a 300kg 12 month old crossbred British breed steers and 30 crossbred wethers when cereal and cereal/vetch crops grown at Culcairn, NSW in 2009 and Temora, NSW in 2010 are fed to 300kg, 12 month old crossbred British breed steers (kg/day) and 30kg crossbred wethers. Note: in 2009 only one plot of Strzelecki/vetch and none of the Wedgetail/vetch and Tobruk/vetch plots and in 2010 none of the Strzelecki/vetch, Wedgetail/vetch and Tobruk/vetch plots were harvested at the dough stage harvest.

changes in both yield and quality over time. It should be noted that these predictions do not include any costs of conserving and feeding the forages.

Conclusions

The yields obtained during dry conditions experienced in 2009 were below normal expectations but much higher than on adjoining pastures (Hackney, personal communication) confirming that cereal and cereal/vetch crops are able to produce good yields even under adverse growing conditions. In 2010, these crops showed their potential to produce very high yields under favourable conditions. Inclusion of vetch did not reduce harvested yield compared with cereal crops in 2009 whereas in 2010 the cereal only crops out yielded cereal/vetch crops by more than 4 t DM/ha. Lodging of crops containing vetch was a problem in 2010 and reduced harvested yield.

The ME content of the 2009 cereal and cereal/vetch crops was high, generally in the range of 10–11 and remained high for most varieties even as the plants matured confirming the anecdotal belief that drought stressed cereal crops are of higher quality than unstressed crops.

In both experiments, the CP content of the cereal only crops was lower than the cereal/vetch crops and in 2009 at the lower end of the normal range observed in cereals. Inclusion of vetch significantly increased CP compared with cereal only crops in both experiments which was clearly reflected in predicted liveweight gain (or loss) of steers and wethers.

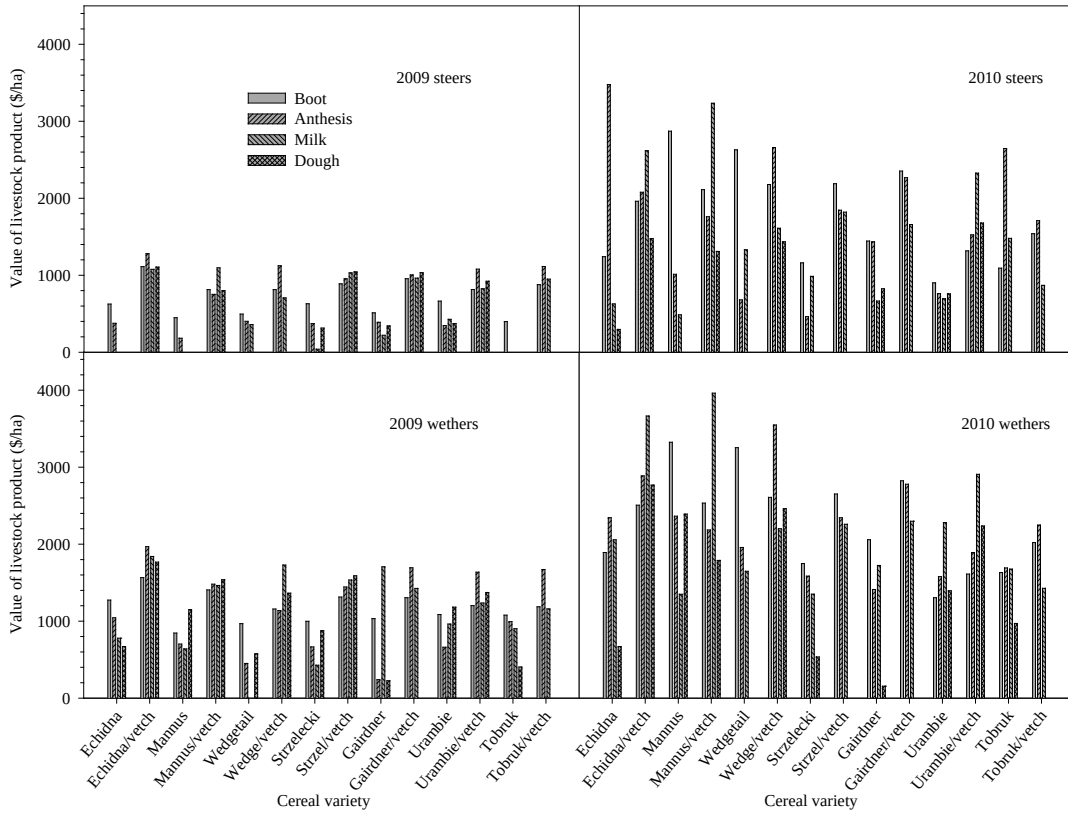

Figure 7. Effect of cereal variety, vetch and harvest on estimated value of livestock production ($/ha) when cereal and cereal/vetch crops grown at Culcairn, NSW in 2009 and Temora, NSW in 2010 are conserved as hay or silage and fed to 300kg, 12 month old crossbred British breed steers (kg/day) and 30kg crossbred wethers. Note: negative values of livestock production from weight loss ignored in these graphs.

Potential livestock production/ha is dependent on yield, energy and protein content of the crops. Assuming that protein in non-limiting then increasing ME by 0.5 MJ kg/DM over the range 9.5–11.0 ME will increase steer and wether liveweight gain by 310 g and 39 g/day, respectively for the class of livestock used as the example in this paper. Increasing yield and ME while ensuring adequate CP content is the key to increasing livestock productivity and production/ha.

The results from these experiments showed that cereal-based forage crops are a viable option for producers wanting to conserve forage for their livestock enterprises. However further research is required to identify best management packages for cereal/vetch crops for hay and silage production. This research needs to include selection of species and varieties, ideal sowing rates, optimum sowing times. This research needs to account for regional/district differences and the impact of seasonal conditions.

Acknowledgments

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