Re-growth yield and nutritive value of winter cereals

Gurhan Keles [AD], *Serkan Ates* [BD], *Behic Coskun* [C] *and Saban Koc* [D]

[A] Faculty of Agriculture, Adnan Menderes University, 09100 Aydin, Turkey
[B] ICARDA, Aleppo, Syria
[C] Faculty of Veterinary Medicine, Selcuk University, 42031 Konya, Turkey
[D] Bahri Dagdas International Agriculture Research Institute, Konya, Turkey
Contact email: gurhan.keles@adu.edu.tr

Abstract. Cereal crops can be grazed in early winter or early spring when feed is scarce, or to utilize their high feeding value. In the early spring of 2011, the re–growth yield and nutritive value of barley (*Hordeum vulgare* L.), rye (*Secale cereale* L.), wheat (*Triticum aestivum*), oat (*Avena sativa* L.), and triticale (x *Triticosecale Wittmack*) grown in the Central Anatolian Region of Turkey, were evaluated after three successive weekly harvests (Cut 1, Cut 2, Cut 3) during the tillering to stem elongation stages. Plants were cut at a height of 5 cm then allowed to re-grow until when they were harvested again at the dough stage on 18 June. Dry matter (DM) production (kg/ha) and nutritive value of forage were compared to plots that were uncut (No Cut). Re–growth yield (DM t/ha) decreased (P<0.01) almost linearly with the delay in cutting time for each crop, but at different (P<0.01) rates. Re–growth was reduced by up to 72% in Cut 3 compared with No Cut. The cell-wall components of plant tissues decreased (P<0.001) in re-growth after Cut 2 and Cut 3 compared with No Cut. *In–vitro* DM digestibility was lowest (P<0.001) in cereals with No Cut at the dough stage. The results suggest that winter cereals can be grazed up to the stem elongation stage without causing large reductions in the overall forage yield. The fodder obtained from material re–grown after the initial grazing may also offer higher-quality feed for livestock than ungrazed crops.

Keywords: Cereal forages, cutting time, defoliation, digestibility, dual purpose.

Introduction

Growing cereal crops for the dual purposes of livestock fodder during the early vegetative stages and harvesting grain at maturity has been a common practice in integrated crop–livestock production systems (Anderson 1985; Harrison *et al*. 2011). Cereal crops are commonly grazed in early spring mainly due to a lack of alternative feed resources for the livestock. The use of cereal forages as one of the primary means of reducing the grazing pressure on rangeland has also been recommended for the Mediterranean basin where rangeland degradation is a widespread problem (Tolu *et al*. 2012). In addition, their high feeding value in early stage of maturity that was also synchronous with most productive period of ruminants can be comparable with concentrate feeding. Therefore, there is increasing value in dual–purpose and/or forage cereal crops as an alternative to traditional grain monoculture, particularly in water-scarce areas of the world (Bonachela *et al*. 1995). If winter cereal forage crops are to be grazed in early spring it is crucial that appropriate management, such as choice of species and cultivar, sowing date, timing and management of grazing, are carefully considered to balance the tradeoffs between early grazing and final forage production.

In this paper, we examined the effect of different harvest times in early spring on the re–growth yield and nutritive value of the cereal forages to establish some simple guidelines for safe grazing or cutting based on phenology.

Methods

The study was conducted at Bahri Dagdas International Agricultural Research Institute research field site (37°51' N; 32°33'E, 1008 m a.s.l.), Konya, Turkey from October 2010 to July 2011. The site was on a clay–loam soil with slightly alkaline characteristics. Soil tests indicated that the site had 2.4% organic matter, 107 kg/ha available phosphorus (P), 277 kg/ha calcium (Ca) and 188 kg/ha potassium (K), soluble salt of 0.05%, and that soil pH (in water) was 7.8. Average mean temperature and monthly rainfall during the growing season are shown in Table 1. Of note was that the rainfall in Konya during spring 2011was greater than the long-term mean and evenly distributed through the spring period providing favourable growing conditions for plant growth.

Crop establishment and experimental design

Following cultivation and seed-bed preparation, cereal grains were planted into 16 x 78 m (0.125 ha) plots using a commercial grain drill with 0.2 m row spacing on 9 November. Based on soil-test results, a total of 100 kg/ha fertilizer (18% N and 46% P_2O_5) was applied at sowing. No additional fertilizer was applied on any later date during the trial. Cereal seeds were sown at rates typical for the region, which were 210 kg/ha for wheat, 200 kg/ha for triticale, 172 kg/ha for rye 166 kg/ha for barley and 146 kg/ha for oats. 2.4–D was applied by small sprayers for weed control in each plot on 12 April. Treatments were arranged in a split-plot design with three replicates. Cereal crops (wheat

Table 1. Average air mean temperature (oC) and monthly rainfall (mm) during the 2010–2011 growing season in Konya, Turkey.

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Temperature (^{o}C)	12.0	8.8	4.6	1.1	1.7	4.6	8.7	13.2	18.4
Rainfall (mm)	71.8	2.4	71.2	37.8	40.4	23.0	44.6	62.6	42.6

Table 2. Dry matter production (DMP) and nutritive value of the cereal crops harvested on 18 April (Cut 1), 25 April (Cut 2), 2 May (Cut 3) or 18 June (not initially harvested, No Cut).

			DMP			Nutritive value*				
Harvest	Crop	Stage of growth†	Initial	Re-growth (t/ha)	Total	CP	NDF	ADF (g/kg)	ADL	DMD
18 April (Cut 1)	Barley	T	2.2	9.2	11.4	92	562	327	58.8	765
	Wheat	T	2.1	12.5	14.6	114	588	353	59.6	784
	Rye	T	2.7	16.2	18.9	85	541	320	65.9	699
	Triticale	T	1.7	14.4	16.1	100	532	301	66.5	756
	Oat	T	1.5	13.5	15.0	92	540	333	56.3	717
25 April (Cut 2)	Barley	SE	5.6	6.7	12.3	92	495	225	48.5	776
	Wheat	SE	5.0	8.7	13.7	103	472	269	49.6	784
	Rye	SE	6.4	6.5	12.9	86	508	281	58.1	733
	Triticale	SE	4.8	9.5	14.3	87	499	257	50.2	784
	Oat	SE	3.9	7.7	11.6	98	517	291	59.7	762
2 May (Cut 3)	Barley	SE	6.7	4.3	11.0	80	517	262	53.8	786
	Wheat	SE	4.8	5.0	9.8	111	470	288	54.4	787
	Rye	SE	7.3	4.0	11.3	112	533	293	64.6	729
	Triticale	SE	5.0	4.6	9.6	94	453	289	50.6	806
	Oat	SE	5.6	4.3	9.9	122	486	279	47.6	812
18 June (No Cut)	Barley	DS	-	-	15.5	85	593	333	69.9	663
	Wheat	DS	-	-	15.6	81	563	350	73.7	675
	Rye	DS	-	-	17.3	71	557	336	112	634
	Triticale	DS	-	-	17.1	90	537	319	76.6	672
	Oat	DS	-	-	16.0	81	575	362	80.6	602
*P*C			*0.04*	*0.01*	*0.01*	*0.02*	0.07	0.06	*0.01*	*0.01*
*P*H			*0.01*	*0.001*	*0.001*	*0.001*	*0.01*	*0.01*	*0.01*	*0.01*
*P*C x H			0.40	*0.01*	0.04	*0.01*	0.12	0.24	0.06	0.41
S.E			0.45	7.42	0.90	6.06	16.9	13.3	5.3	18.1
LSD (5%)[1]			1.30	2.13	2.56	17.3	48.5	38.0	15.1	51.8
LSD (5%)[2]			1.37	2.24	2.74	18.0	50.5	37.6	15.8	56.3

CP: Crude protein; NDF: Neutral detergent fibre; ADF: Acid detergent fibre ADL: DMD Dry matter digestibility; DMP: Dry matter production. *Chemical composition of the plants harvested on 18 June. [1]Respective least significant differences for comparing crop x harvest means and [2]for comparing means within the same level of crop.† T: tillering; SE: stem elongation; DS: dough stage.

"Goksu", triticale "Tatlicak", rye "Aslim", barley "Beysehir" and oat "Faikbey") were the main plot factor and the weekly cutting time (Cut 1, 2, 3 and No Cut) was the sub-plot factor. On 18 April (Cut 1), 25 April (Cut 2) and 2 May (Cut 3) at the tillering and stem elongation stages, a single 50 cm strip was selected at random from each plot and trimmed to a 50 mm stubble height with a 0.9 m wide sickle–bar mower. All the freshly cut plant material was weighed immediately on a platform scale and sub–samples of each forage crop were dried to constant weight at 60°C for 48 hours to determine the percentage of dry matter (DM). These subplots were then allowed to re-grow for a period of seven weeks after Cut 3. On 18 June when the crops were at dough stage of development (Zadocks 85), final DM production was determined by cutting three randomly placed 0.2 m^2 quadrats within the subplots cut to 50 mm residual height with sickles. Control plots previously uncut (No Cut) were also harvested at this time. The sampled biomass was weighed and dried as previously. Crude protein (CP) was determined by Kjeldahl method

(AOAC, 2003). Neutral detergent fibre (NDF), acid detergent fibre (ADF) and acid detergent lignin (ADL) were assayed according to Van Soest *et al*. (1991). The NDF was expressed with the inclusion of a heat-stable amylase and sodium sulfite, but both NDF and ADF expressed inclusive of residual ash. In vitro true DM digestibility (DMD) was determined with the DAISY[11] incubator with ruminal fluid. Dry matter production and nutritive value of the forages were analyzed by ANOVA with three replicates of a split-plot design where cereal crops were the main plot factor and the cutting time was the sub-plot factor. Where ANOVA was significant, means were separated by Fisher's protected LSD at α=0.05.

Results

Initial DM production of cereal forage crops harvested on 18 April, 25 April and 2 May ranged between 1.5 (oat on 18 April) and 7.3 t/ha (rye on 2 May) and differed among crops (P<0.05) and harvest treatments (P<0.01). Re–growth yield (DM t/ha), measured on 18 June decreased (P<0.01) almost linearly with the delay in the spring harvest for each cereal crop, but at different (P<0.01) rates. Compared with No Cut, re–growth yield of cereal forages were 20%, 52% and 72% lower for Cut 1 (18 April), Cut 2 (25 April) and Cut 3 (2 May), respectively. This was similar to the findings of Baron *et al*. (1995) who reported major reductions in combined re–growth yield of various cereal forages as the initial harvest was delayed, particularly after the heading stage of growth. All forage crops except barley had high re–growth yields (79–110% DM production of uncut forages) following Cut 1, providing a similar total harvested DM production (initial plus re–growth) to the No Cut treatments. Following Cut 2 on 25 April, triticale and wheat exhibited more resilience than others, accumulating 55% DM production of uncut forages. The total harvested dry matter production of all cereal crops following the Cut 3 was lower (P<0.01) than those had not been harvested in early spring (No Cut).

There were significant differences (P<0.01) in total DM production (t/ha) and forage nutritive value between the forage crops and harvest treatments. The crude protein contents of the re–grown forage of Cut 3 were higher (P<0.001) than that which had not been previously cut in spring for rye, oat and wheat, while the crude protein content did not differ between harvests for triticale and barley. Concentrations of NDF and ADF of the cereal crops were similar for the No Cut and Cut 1 treatments but further delay in harvest reduced the NDF and ADF content of the forages by up to 17% compared with No Cut and Cut 1. In vitro dry matter digestibility was the lowest (P<0.001) in cereals with No Cut at the dough stage. The changes in nutritive quality parameters in this study were in line with the results of Francia *et al*. (2006) who reported that barley plants showed lower fibre content following two grazings. The increased nutritive quality of the re–grown material is possibly due to less structural carbohydrate content of the cereal plants.

Conclusion

The results indicate that cereal forages can provide high-quality forage in early spring enabling farmers to overcome feed shortages at that time of year. Grazing winter forage cereals up to the stem elongation stage may provide early spring feed for livestock without causing huge reductions in the overall forage yield. In addition, the fodder obtained from the re–grown material after the initial grazing may offer higher-quality feed for livestock. However, considerable variation exists between cereal forages for their re–growth potentials and nutritive values following cutting at tillering and stem elongation stages of growth in early spring. Barley appeared to be the least resilient species to early grazing but the choice of forage species will depend on the desired outcome and the agro–ecological factors.

Acknowledgements

This study was supported by the Scientific and Technological Research Council of Turkey (TUBITAK). The authors thank to Dr. Murari Singh for providing advice on statistical analyses.

References

AOAC (2003) Official Methods of Analysis of AOAC International. 17th Ed. 2nd Rev., Gaithersburg, MD, USA, Association of Analytical Communities.

Anderson WK (1985) Production of green feed and grain from grazed barley in northern Syria. *Field Crops Research* **10**, 57–75.

Baron VS, Remy EA de St. Salmon DF, Dick AC (1995) Delay of harvest effects on forage yield and regrowth in spring and winter cereal mixtures *Canadian Journal of Plant Science* **75**, 667-674.

Bonachela S, Orgaz F, Fereres E (1995) Winter cereals grown for grain and for the dual purpose of forage plus grain I. Production *Field Crops Research* **44**, 1-11.

Francia E, Pecchioni N, Nicosi O Li Destri, Paoletta G, Taibi L, Franco V, Odoardi M, Stanca AM, Delogu G (2006) Dual–purpose barley and oat in a Mediterranean Environment. *Field Crops Research* **99**, 158-166.

Harrison MT, Evans JR, Dove H, Moore AD (2011) Dual-purpose cereals: can the relative influences of management and environment on crop recovery and grain yield be dissected. *Crop and Pasture Science* **62**, 930–946.

Tolu C, Yurtman IY, A, Baytekin H, Atasoglu C, Savas T (2012) Foraging strategies of goats in a pasture of wheat and shrubland. *Animal Production Science* **52**, 1069–1076.

Van Soest PJ, Robertson JB, Lewis BA. (1991). Method for dietary fiber, neutral detergent fiber, and nonstarch polysaccharides in relation to nutrition. *Journal of Dairy Science* **74**, 3583-3597.