Forage Quality of Cereal–Common Vetch at Different Age and Proportions

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Abstract

Cereal plant age at harvesting and the proportion of vetch in the harvested forage from cereal-common vetch mixtures might influence total forage quality. The objectives were to determine forage of a forage mixture cereal-vetch, from cereal harvested at two development stages and vetch at different proportion. Cereals were oats and triticale, cultivars: Chihuahua, Bicentenario and Siglo XXI, the last two were triticale; cereal development stages at harvest were: 50% flowering and hard grain. Vetch was harvested at two development stages: 100% flowering and pod formation, while vetch proportions in the forage mix were: 0, 0.25, 0.5, 0.75 and 1.0. Forage quality measures were: crude protein (CP), neutral detergent fiber (NDF), organic matter (OM), ether extract (EE) and dry matter digestibility (DMD). Statistical analysis was by linear regression; cereal cultivar was a categorical variable. Models developed showed a $R^2 \geq 0.7871$. As vetch proportion increased in the mix so did CP while NDF decreased, CP increased from 9.2 to 17.5% and 9.2 to 14.4% and NDF decreased from 71.4 to 57.6% and 79.1 to 58.9%, as vetch proportion increased, when cereal was harvested at 50% flowering and grain hard, respectively. OM and EE showed small changes over vetch proportion and cereal development stage. DMD showed major ($p<0.05$) changes with cereal development stage at harvesting. It was concluded that forage quality of cereal-vetch mix depends on vetch proportion and stage of development of the cereal at the time of harvest.

Introduction

Rain-fed small grain cereals-common vetch mixture hay is a widespread option for many goat and sheep smallholders farmers to feed their herds during the dry season. This crop mixture has been shown to provide forage of enough quality to meet nutritional requirements of mature animals. However, cereal maturity at the time of harvest and the proportion of vetch in the mixture influence on the forage quality profile of the forage produced (Carpici and Celik, 2014; Alzueta *et al*., 2001). The development of a model that provides a quantitative profile of forage quality at different cereal maturity and proportion of vetch could become a useful tool to decide crop management of this mixture. Linear regression analysis could be a pertinent statistical method to develop such a model (Mayers, 1990). Then the objective of the study was to determine by a statistical model the quantitative influence on forage quality of cereal plant maturity and common vetch proportion in the mixture cereal-vetch hay.

Methods and Study Site

All forage samples came from plots where species used were grown as single crops under local common rain-fed crop management guidelines. Cereals were oats (*Avena sativa* L.) and triticale (*xTriticosecale* Wittmack), oats cv was Chihuahua and two cultivars of triticale: Bicentenario and Siglo XXI. A local material of common vetch (*Vicia* sativa L.) was used. Two times of harvest were applied to cereals: 50% flowering and hard grain. In vetch there were also two times of harvest: full flowering and pod formation. Vetch forage was mixed with cereal forage at the following proportions: 0, 0.25, 0.50, 0.75 and 1.00. Harvest was at ground level, and the mixtures were done after forage of each species was oven-dried and ground to pass a 1 mm screen.

Mixtures made were analyzed for crude protein (CP), neutral detergent fiber (NDF), organic matter (OM), ether extract (EE) and dry matter digestibility (DMD).

Statistical analysis was by linear regression under the model $Y_{ij} = \beta_0 + \beta_1 X_i + \beta_2 D_j + \beta_3 X_i D_j + \varepsilon_{ij}$; *Y,* is the value of the specific forage quality measurement; *X*, is the proportion of vetch in the mixture; *D,* categorical variable of cereal entry. Coefficients (β) were tested against a value of 0, in all the cases at probability of 0.05.

Results

Cereal entry X vetch proportion interaction was significant ($p<0.05$) on all forage quality measurements. Then, models for each cereal entry were developed (Tables 1 to 3) major differences ($p<0.05$) were found when mixtures had no vetch added and also there were differences ($p<0.05$) in the rate of change in the forage quality measurements as vetch proportion in the mixture increased. Most of the regression models were significant ($p<0.05$) and explained more of 70% of the total variability of each forage quality measurement ($p<0.05$). The crude protein (CP) increased at different rate, but organic matter (OM), neutral fiber detergent (NDF) and extract ether (EE) decreased at different rates with increasing common vetch from 0 to 100 g.

Table 1. Regression coefficients of linear models from common vetch in mixture from a proportion of 0 to 1 with three cereals entries harvested at 50% flowering and the common vetch at full flowering

Cereal entry	a	b	R^2
Organic matter (%)			
Oat Chihuahua	$82.48 \pm 1.06^{b***}$	-0.0462 ± 0.0173^{aNS}	0.7043
Triticale Bicentenario	$83.96 \pm 1.12^{ab***}$	$-0.0608 \pm 0.018^{a*}$	0.7871
Triticale Siglo XXI	$85.07 \pm 0.83^{a***}$	$-0.0603 \pm 0.012^{a*}$	0.9224
Crude protein (%)			
Oat Chihuahua	$9.53 \pm 0.38^{c***}$	0.099 ± 0.006^{aNS}	0.7043
Triticale Bicentenario	$10.60 \pm 0.29^{b***}$	$0.086 \pm 0.004^{b*}$	0.9923
Triticale Siglo XXI	$12.67 \pm 1.62^{a**}$	0.064 ± 0.026^{cNS}	0.6597
Neutral detergent fiber (%)			
Oat Chihuahua	$71.64 \pm 1.09^{b**}$	$-0.189 \pm 0.016^{a**}$	0.856
Triticale Bicentenario	$68.58 \pm 2.57^{b***}$	-0.167 ± 0.042^{bNS}	0.6597
Triticale Siglo XXI	$77.05 \pm 3.59^{a**}$	$-0.225 \pm 0.055^{a*}$	0.8301
Ether extract (%)			
Oat Chihuahua	$1.96 \pm 0.28^{a**}$	-0.002 ± 0.004^{aNS}	0.0462
Triticale Bicentenario	$1.30 \pm 0.20^{b*}$	-0.005 ± 0.003^{aNS}	0.5600
Triticale Siglo XXI	$1.99 \pm 0.30^{a*}$	0.0001 ± 0.0048^{bNS}	0.0001

a = Forage quality measurement at 0 proportion of common vetch; b = Rate of change of forage quality measurement as vetch proportion increased. R^2 = Variability explained by the model, *p<0.05, ** p<0.05, ***p<0.001, NS = no significant (p>0.05).

Table 2. Regression coefficients of linear models from common vetch in mixture from a proportion of 0 to 1 with three cereals entries harvested at hard grain hard and common vetch at pod formation

Cereal mixed with vetch	a	b	R^2
Organic matter (%)			
Oat Chihuahua	$85.65 \pm 1.01^{a**}$	-0.031 ± 0.020^{aNS}	0.01563
Triticale Bicentenario	$80.94 \pm 1.86^{b**}$	0.0038 ± 0.030^{cNS}	0.9636
Triticale Siglo XXI	$80.31 \pm 3.54^{b***}$	-0.0097 ± 0.058^{bNS}	0.0093
Crude protein (%)			
Oat Chihuahua	$8.77 \pm 0.37^{a***}$	$0.072 \pm 0.006^{b*}$	0.9786
Triticale Bicentenario	$7.36 \pm 0.64^{b**}$	$0.093 \pm 0.010^{a*}$	0.9636
Triticale Siglo XXI	$6.95 \pm 0.87^{b**}$	$0.085 \pm 0.014^{a*}$	0.9227
Neutral detergent fiber (%)			
Oat Chihuahua	$65.65 \pm 1.59^{b***}$	$-0.110 \pm 0.026^{b*}$	0.8576
Triticale Bicentenario	$79.65 \pm 1.58^{a***}$	$-0.242 \pm 0.026^{a*}$	0.9672
Triticale Siglo XXI	$77.05 \pm 3.59^{a***}$	$0.225 \pm 0.059^{a*}$	0.8301
Ether extract (%)			
Oat Chihuahua	$3.04 \pm 0.14^{a***}$	$-0.0095 \pm 0.0022^{a*}$	0.8587
Triticale Bicentenario	$1.31 \pm 0.19^{b*}$	0.0062 ± 0.0032^{bNS}	0.5527
Triticale Siglo XXI	$1.22 \pm 0.08^{b**}$	$0.0083 \pm 0.0013^{ab*}$	0.9260

a = Forage quality measurement at 0 proportion of common vetch; b = Rate of change of forage quality measurement as vetch proportion increased. R^2 = Variability explained by the model, * $p<0.05$, ** $p<0.05$, ***$p<0.001$, NS = no significant ($p>0.05$).

Models for dry matter digestibility were different ($p<0.05$) in the coefficient a, DMD of mixture when vetch proportion in the mixture was 0, and the trend was to a lower DMD when cereal was harvested at hard grain (Table 3). Rate of change as vetch proportion in mixture changed (coefficient b) only in one model was different ($p<0.05$) to 0 (Table 3).

Table 3. Regression coefficients for dry matter digestibility models three cereal entries harvested at two stages and vetch proportion increments from 0 to 1.

Cereal entry	Cereal stage	a	b	R^2
Oat Chihuahua	50% flowering	$67.64 \pm 1.17^{a***}$	-0.023 ± 0.019^{cNS}	0.3335
Oat Chihuahua	Hard grain	$52.29 \pm 2.64^{b***}$	0.054 ± 0.043^{bNS}	0.3413
Triticale Bicentenario	50% flowering	$55.27 \pm 4.52^{a*}$	0.088 ± 0.067^{aNS}	0.4651
Triticale Bicentenario	Hard grain	$60.62 \pm 4.32^{a*}$	$-0.028 \pm 0.064)^{bNS}$	0.0896
Triticale Siglo XXI	50% flowering	$51.51 \pm 2.00^{b***}$	$0.121 \pm 0.033^{a*}$	0.8205
Triticale Siglo XXI	Hard grain	$64.58 \pm 3.92^{a**}$	-0.056 ± 0.064^{bNS}	0.4460

a = Dry matter digestibility at 0 proportion of vetch; b = Rate of change of dry matter digestibility as vetch proportion increased. R^2 = Variability explained by the model, * $p<0.05$, ** $p<0.05$, ***$p<0.001$, NS = no significant ($p>0.05$).

Discussion

In all cereal entries the increase in the proportion of vetch in the mixture originated a higher crude protein and lower NDF, this trend agrees with the findings of Carpici and Celik (2014) and Alzueta *et al*., (2001). However, proportion of vetch in the mixture showed no influence on dry matter digestibility. Inclusion of vetch to cereal hay is a way to improve forage quality of such hay, then growing both forage crops as a mixed crop could benefit sheep and goat farmers as a better quality hay could be provided to their herds

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