WINTER FORAGE QUALITY OF OATS (*AVENA SATIVA*), BARLEY (*HORDEUM VULGARE*) AND VETCH (*VICIA SATIVA*) IN PURE STAND AND CEREAL LEGUME MIXTURE

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ABSTRACT:- A field study was carried out for two consecutive years in subtropical rainfed conditions of Rawalpindi, Pakistan to evaluate the forage quality of oats, barley and vetch grown in pure stands and cereal-legume mixtures. Treatments comprised oats pure stand, oats in oats-vetch mixture, barley pure stand, barley in barley-vetch mixture, vetch pure stand, vetch in oats-vetch mixture and vetch in barley-vetch mixture. Forage yield and quality of oats and barley were improved in oats-vetch and barley-vetch mixtures than their respective pure stands. The higher values of crude protein (CP) and lower values of neutral detergent fiber (NDF) and acid detergent fiber (ADF) reflected quality forage. CP for oats in oats-vetch mixture and barley in barley-vetch mixture was 175 g kg^{-1} and 170 g kg^{-1}, respectively. NDF and ADF for oats in oats-vetch mixture were 494 g kg^{-1} and 341 g kg^{-1}, respectively; while these values for barley in barley-vetch mixture were 340 g kg^{-1} and 176 g kg^{-1}, respectively.

Key Words: Oats; Barley; Vetch; Forage Quality; Crude Protein; Neutral Detergent Fiber; Acid Detergent Fiber; Cereal-Legume Mixture; Crop Yield; Pakistan.

INTRODUCTION

The quality of forages can be improved by cereal-legume mixture, supply of farm byproducts and use of concentrates (Mpairwe et al., 2003; 2003a). The former is the most cost-effective while latter two are the scarcest and limiting factors.

Forages is one of the main problems in rainfed areas especially in subtropical Pothwar areas of Pakistan. In addition, the natural vegetation is generally unable to meet the nutritional requirements of farm animals. The most of farmers are using cereal hay for their animals which too is substandard (Lithourgidis et al., 2006). Cereal-legume mixture is a sustainable solution in such situations to meet the shortage of forage (Yadav and Yadav, 2001). Cereal-legume mixture has shown the improvement in qualitative characteristics of forage (Ansar et al., 2013). Quality forage may be achieved by cereal-legume mixture (Mpairwe et al., 2003) while pure cereal stands are deficient in crude protein (Umunna et al., 1997).

Presently, there is an increasing interest in sustainable agriculture especially for cereal-legume mixture to obtain maximum cost effective production. Several benefits by legumes in mixture were noticed such

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as soil fertility by nitrogen-fixation, high land use efficiency and high yield (Ghosh, 2004). In cereal-legume mixture, high land use efficiency to increase yield was observed by Javanmard et al. (2009). The mixcropping resulted in increased water and nutrient uptake and thus, it conserved the soil (Vasilakoglou et al., 2005). Vetch with cereals, facilitates the forage growth and improve forage quality whereas cereals in return provide advantages as, structural support, better light interpretation and harvesting (Thompson et al., 1992). However, insufficient and limited investigation on cereal-legume mixtures for forage yield and quality has been carried out in subtropical dry regions, Pothwar of Pakistan.

The objective of the research was to investigate the forage yield and quality of oats and barley facilitating with vetch since there is a dire need for strategic quality forage supplementation through cereal legume mixture to improve animal health.

MATERIALS AND METHOD

The experiment was carried out at the PMAS-Arid Agriculture University, Research Farm, Koont (73° 05´ E and 33° 38´ N) during winter 2012-2013 and 2013-2014. The soil of the site was loam, classified as Rawalpindi soil series typic Ustocrepts, (GoP, 1974). The site is located in a subtropical rainfed region (Table 1). The rainfall recorded during both years of experimentation showed bi-model behavior with two maxima, one in late summer (August and September) and second during the winter-spring (February and March) (Figure 1). The field layout was arranged in factorial design with four replications. Single plot size was 72 m^2 and 20 plots were maintained per replication. Winter wheat was the previous grown crop and was harvested in the last week of April, 2012 and straw of wheat was removed after harvest.

The crop varieties under study were oats (*Avena sativa*; cv. PD_2LV_{65}), barley (*Hordeum vulgare*; cv. Jau-86) and vetch (*Vicia sativa*; cv. Languedock). The proportions of cereal and legumes in mixture were 70% both for oats and barley, and 30% for vetch i.e., 2.3:1 ratio (Table 2). In mixture treatments, both component crops were analyzed separately for quality parameters. Cereal-legume treatments were: Oats pure stand (O_1), oats in oats-vetch mixture (O_2), barley pure stand (B_1), barley in barley-vetch mixture (B_2), vetch pure stand (V_1), vetch in barley-

Table 1. Physicochemical properties of experimental site recorded during 2012-13 and 2013-14

Parameter	2012-13		2013-14	
Soil depth (cm)	0-15	15-30	0-15	15-30
EC (dS m^{-1})	0.76	0.87	1.23	0.98
Organic matter (g 100 g^{-1})	0.68	0.59	0.66	0.61
Available P (mg kg^{-1})	7.42	7.31	7.96	7.87
Available K (mg kg^{-1})	113.50	115.50	112.50	113.50
Texture	Loam	Loam	Loam	Loam

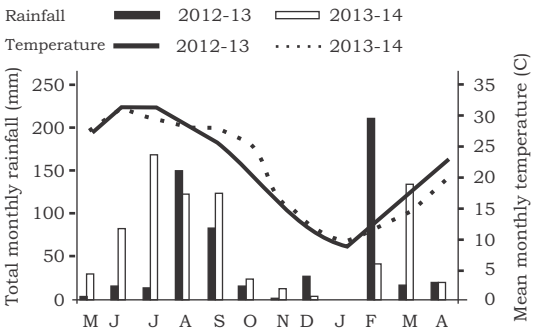

Figure1. Total monthly rainfall (mm) and mean temperature (°C) during two years of study

vetch mixture (V_2) and vetch in oats-vetch mixture (V_3).

The crops were sown with conventional winter seed drill at row to row distance of 22.5 cm on October 23, 2012 and October 28, 2013. The experiment was carried out in the same field during both years. The seed were used @ 40kg ha^{-1} and 15kg ha^{-1}, respectively for cereals and vetch and were treated with Topsin-M @ 2g kg^{-1} before sowing to control fungal diseases. The fertilizer dose @ 120-80 kg NP ha^{-1} for cereal crop and 0-40 kg NP ha^{-1} for vetch crop, respectively, were applied before sowing of crops. Forage crops were harvested on February 19, 2013 and February 26, 2014.

Two samples from 1m^2area were taken randomly from each plot and their fresh weight was recorded. For quality parameters, the fresh plant samples of oats and barley at booting stage while vetch at flowering stage from each plot were collected and oven-dried at 65 °C for 72 h and ground samples were used for quality analysis. The N was determined using the Kjeldahl method (Bremner, 1965) and the crude protein (CP) was calculated by multiplying the N by a conversion factor 6.25 (AOAC, 1980) while neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined by fluxing technique using hot plate (Goering and Van Soest, 1970). Total digestible nutrients (TDN), and relative feed value (RFV) were calculated by Horrocks and Vallentine (1999) equations as under:

$$TDN = (-1.291 \times ADF) + 101.35$$

RFV = % digestible dry matter (DDM) × % dry matter intake (DMI) × 0.775

Statisix 8.1 (Tallahassee, Florida,

Table 2. Forage crops sown in pure stand and in combinations during experiment

S. No.	Seed %	Culture	Forage		Cultivar
			Common name	Botanical name	
1	100b	Mono	Barley	*Hordeum vulgare*	Jau-86
2	100o	Mono	Oats	*Avena sativa*	PD_2LV_{65}
3	100v	Mono	Vetch	*Vicia sativa*	Languedock
4	30v+70b	Binary	Barley-vetch	*Hordeum vulgare*-*Vicia sativa*	Jau-86-Languedock
5	30v+70o	Binary	Oats-vetch	*Avena sativa*-*Vicia sativa*	PD_2LV_{65}-Languedock

b = barley, o = oats and v = vetch

USA) software was used for analysis of variance (ANOVA) in factorial design. Means were compared at 5% significance level by least significant difference (LSD) test (Steel et al., 1997).

RESULTS AND DISCUSSION

The significant increase was recorded in forage yield of oats in oats-vetch mixture over oats grown in pure stand (Table 3). Oats grown in mixture showed better forage yield (50.10 t ha^{-1}) than oats grown in pure stand (44.34 t ha^{-1}). Cereal-legume mixture showed 16% higher green forage yield of oats in oats-vetch mixture. Similarly, barley in combination with vetch resulted in higher forage yield than barley grown in pure stand. Higher forage yield of barley in barley-vetch mixture was 39.84 t ha^{-1};while, in pure barley stand forage yield was 29.20 t ha^{-1}. The increase in forage yield due to cereal-legume mixture was 38%. The highest yield of 30.62 t ha^{-1} of vetch was produced in pure stand while lower 7 t ha^{-1} was recorded in both mixtures.

The results indicated that oats, barley and vetch produced in pure stand and in cereal-legume mixtures showed statistically significant differences for yield and quality. Among both the cereals, oats in pure stand gave 20% higher forage yield than barley in pure stand which may be due to relative higher plant height. Yields of both oats and vetch (or barley and vetch) were studied individually in cereal-legume mixture; while other scientists studied cereal-legume mixture in combined form. The higher forage yield of oats (or barley) in oats-vetch mixture (or barley-vetch mixture) was probably due to the nitrogen contribution by vetch through atmospheric nitrogen fixation. These results are in agreement with Ansar et al. (2013) who stated that higher forage yield in mixture was due to legume. Moreover, Lodhi et al. (2009) also reported higher yield in oats-vetch mixture than vetch pure stand. Previously, Bakhsh et al. (2007) stated that PD_2LV_{65} gave high forage yield with vetch. It was considered that forage yield of oat differed due to variation of number of leaves and plant height (Hussain et al., 2011). Similarly, Nadeem et al. (2010) found comparatively higher yield of oats-vetch mixture than barley-vetch mixture. The lush green appearance of oats in oats-vetch mixture, showed more chlorophyll contents and hence more yield. Ahmad et al. (2011) reported increased yield due to more nitrogen contributed by legume. However, Giacomini et al. (2003) reported that forage yield of oats-vetch mixture was similar to that of oats pure stand but greater than vetch pure stand. Anwar et al. (2010) revealed that oat-vetch mixture produced 16% higher forage yield than oats with broad leaves legume.

The decrease of vetch forage yield in the cereal-legume mixture was probably due to shading effect of both oats and barley which caused senescence of lower branches of vetch. Cereals are more competitive than vetch for natural resources especially light and space which negatively affected the vetch yield. The low availability of light resulted in chlorosis and necrosis in vetch. The negative effect of barley on vetch yield was smaller than oats due to relatively thinner canopy.

The significant increase was recorded in crude protein (CP) of oats

Table 3. Yield and quality parameters of forages in cereal-legume mixture

Cereal-legume	Yield (t ha^{-1})	Crude protein (g kg^{-1})	Neutral detergent fiber (g kg^{-1})	Acid detergent fiber (g kg^{-1})	Total digestible nutrients (g kg^{-1})	Relative feed value (%)
Oats pure stand	44.34[b]	140.04[b]	515.22[a]	385.27[a]	51.61[B]	106.33[B]
Oats in oats-vetch stand	50.10[a]	175.08[a]	493.89[b]	340.58[B]	57.38[A]	117.45[a]
Barley pure stand	29.20[b]	159.87[a]	439.41[a]	241.71[a]	70.15[B]	148.34[B]
Barley in barley-vetch stand	39.84[a]	170.34[b]	340.00[b]	176.44[B]	78.57[a]	205.64[a]
Vetch pure stand	30.62[a]	245.57[a]	395.18[c]	305.89[C]	61.86[a]	153.19[a]
Vetch in oats-vetch stand	07.00[b]	226.50[b]	405.81[b]	315.87[B]	60.57[B]	147.40[B]
Vetch in barley-vetch stand	06.97[b]	225.35[b]	425.29[a]	325.57[A]	59.32[C]	138.99[C]

Means followed by same letter do not differ significantly at 5% level of probability

in oats-vetch mixture than oats in pure stand (Table 3). Considering variation due to cereal-legume mixture in two years, higher CP of 175 g kg^{-1} in oats-vetch mixture, while lower 140 g kg^{-1} in oats pure stand was recorded. The CP in oats-vetch mixture improved the nutritive quality of oats forage compared with cereal forage grown in pure stand. The oats grown in oats-vetch mixture had 25% higher CP than pure oats stand. Similarly, barley in combination with vetch resulted in higher CP than barley grown in pure stand. Higher CP of barley in barley-vetch mixture was 170 g kg^{-1} while in pure barley it was 160 g kg^{-1}. Barley with vetch showed 7% higher CP than pure barley stand. The CP for pure vetch was significantly higher (245 g kg^{-1}) than vetch produced in barley-vetch mixture (226 g kg^{-1}) or vetch in oats-vetch mixture (225 g kg^{-1}) indicating non-significant differences for vetch grown with oats and barley. The pure vetch stand showed 9% higher CP than vetch with oats and 8% higher CP than vetch with barley.

A significant decrease was recorded for neutral detergent fiber (NDF) and acid detergent fiber (ADF) of oat in oat-vetch and barley in barley-vetch mixtures as compared to oat and barley pure stands (Table 3). Lower NDF and ADF were recorded in oats-vetch mixture than pure oats stand. Oat in oat-vetch mixture produced mean minimum NDF and ADF of 493 and 340 g kg^{-1}, respectively. The oats-vetch showed 4% and 12% lower NDF and ADF, respectively, than pure oats. Barley with vetch mixture showed 23% and 27% lower NDF and ADF, respectively, than pure barley. Similarly, lower NDF (340 g kg^{-1}) and ADF (176 g kg^{-1}) were produced by barley in barley-vetch mixture while higher NDF (439 g kg^{-1}) and ADF (241g kg^{-1}) were produced in pure barley. On the contrary, the lowest NDF (395g kg^{-1})and ADF (305g kg^{-1}) were produced in pure vetch. The highest NDF and ADF were produced by vetch in oats-vetch mixture with 425 and 325g kg^{-1}, respectively. Vetch in barley-vetch mixture produced NDF

and ADF of 405.81 and 315g kg^{-1}, respectively. The results indicated that pure vetch showed 8% lesser NDF than oats-vetch mixture and 3% lesser NDF than barley-vetch mixture. Results clearly indicated that oats-vetch mixture exhibited 6% higher ADF than pure vetch and barley-vetch mixture that showed 3% higher ADF than pure vetch. As low neutral detergent fiber (NDF) and acid detergent fiber (ADF) are desired characteristics for quality forage. The dry matter intake increases in animals with the decrease of NDF. Present findings about lower NDF and ADF are in line with Mpairwe et al. (2003 and 2003a) who concluded that lower NDF and ANF were result of cereal-legume mixture rather than only grass. Similarly, superiority of cereal-legume mixture was recorded by obtaining higher CP and lower NDF in oats-vetch mixture than grass hay (Mpairwe et al., 2003) and recommended oats-vetch mixture as quality forage. Present results differed with those of Lithourgidis et al. (2006) who reported higher NDF in legumes as compared to cereals.

A significant increase was observed for total digestible nutrients (TDN) of oats in oats-vetch and barley in barley-vetch mixtures than their respective pure stands (Table 3). The TDN for oats in oats-vetch mixture and barley in barley-vetch mixture were 57 and 78 g kg^{-1}, respectively. TDN of oats in oats-vetch mixture was 11% higher than pure oats while in barley with vetch mixture, 12% higher TDN was recorded than pure barley. In addition, the values of TDN for pure vetch stand were 61g kg^{-1}. The TDN for vetch in barley-vetch mixture was 60 g kg^{-1} and for vetch in oats-vetch mixture were 59 g kg^{-1}. The decline of TDN was 4% and 2% for vetch in oats-vetch and barley-vetch mixture, respectively. High TDN reflects the quality of forage. The TDN reflects the presence of ADF. Results showed that relation between TDN and ADF was antagonistic. The TDN is used to represent available nutrients for farm animals (Surmen et al., 2013). The decline in ADF showed an increase in TDN which refers maximum forage nutrients utilization by livestock. In this study, higher TDN was observed both for oats and barley in cereal-legume mixture.

The significant increase was recorded for relative feed value (RFV) of oats in oats-vetch and barley in barley-vetch mixture than their respective pure stands (Table 3). The percentages of RFV of oats in oats-vetch mixture and barley in barley-vetch mixture were 117 and 205, respectively. RFV was 11% higher in oats-vetch mixture than pure oats stand. RFV of barley-vetch mixture was 39% higher than pure barley. Similarly, the RFV for vetch in pure stand, vetch in barley-vetch and oats-vetch mixture were 153%, 147% and 138%, respectively. RFV in vetch was 9% higher than vetch in oats-vetch mixture and 4% higher than vetch in barley-vetch mixture.

High crude protein (CP) is an important aspect used to reflect quality forages especially cereal-legume mixture (Malézieux et al., 2009; Yolcu et al., 2009; Ayan et al., 2012). The increased CP of oats and barley reflected increased nitrogen concentration in soil due to atmospheric nitrogen fixation by vetch. Lithourgidis et al. (2011) stated that pea-wheat with 80:20 mixtures produced higher CP than pure wheat

and the increased pea proportion in mixture produced high CP. For the same reason, pea was mixed with cereal (Carr et al., 2004). These results concur with the findings of Mpairwe et al. (2003) who stated that higher CP was recorded due to legume contribution towards grass in cereal-legume mixture, Mpairwe et al. (2003a) and Turk and Albayrak (2012) also reported improved CP in oats-vetch mixture. In pure cereal, Fageria and Baligar (2005) found that higher dry matter yield resulted in decreased plant nitrogen and CP. This means that pure cereal produces the higher dry matter and lesser nitrogen than cereal-legume mixture. In contrast, Li et al. (2006) observed non-significant differences for nitrogen both in cereal-legume mixture and pure cereal stand.

The NDF has antagonistic relation, the lower NDF results in high forage quality. RFV is an indicator that is used to estimate intake of forage and its energy. RFV has six categories with respect to their quality viz., rejected, poor, fair, good, premium and prime, and with values less than 75, 75-86, 87-102, 103-124,125-150 and more than 151, respectively (Uzun, 2010). RFV of oats and barley indicated good and prime quality forages in cereal-legume mixture while vetch showed prime quality in pure stand.

Crude protein (CP) content in pure vetch stand was higher than vetch plants produced in barley-vetch and oats-vetch mixtures. High crude protein content reflects quality forage. The palatability and digestibility are greater in the forage containing high crude protein. Higher CP was observed in pure vetch stand where the plants obtained optimum light and showed maximum photosynthetic activity, while on the other hand in mixture, the fast growth of cereals hinder the light to reach the vetch and hence reduced the photosynthetic activity of vetch which resulted in chlorosis in the lateral younger branches and senescence of their leaves. The lower quality in vetch in mixture was also due to early necrosis and decaying started at small branches of vetch plant in mixture. These results concord with those of Lithourgidis et al. (2011), who found higher CP in pure pea than in wheat-pea mixture. The high crude protein of pure vetch was the result of the maximum benefit of nitrogen fixation by their root nodules which was shared with cereals in mixture. Similar findings were reported by Iptas et al. (2002), Iptas and Brohi (2003), Almodares et al. (2009) and Glamoclija et al. (2011) who observed an increase of crude protein with increasing nitrogen in soil.

It was thus concluded that forage produced from cereals in mixture with legume is of better quality when compared with their pure stands.The quality of vetch showed antagonistic response to cereal-legume mixture as the quality of pure vetch stand was significantly superior to both of its mixtures with cereals (oats and barley). The findings of present study clearly indicated the effectiveness of cereal-legume mixture to improve the quality of cereals (oats and barley) forages than grown in pure stands while the reverse is true for vetch. It is recommended that farmers should adopt oats-vetch mixture and barley-vetch mixture for better yield and quality of oats and barley while pure stand for vetch.

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