FORAGE YIELD AND QUALITY PERFORMANCE OF *RABI* CEREALS SOWN ALONE AND IN BLENDED POPULATION AT VARIABLE SEED RATIOS

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ABSTRACT:- Fodder crops are the main source of animal feed in Pakistan. However, the yield per acre is still far below than optimum production level of the livestock. From this perspective, a field trial was conducted using seeds of three cereal crops wheat, oat and barley sown alone and blended together at different seed proportions (100%: 0%, 75% + 25%, 50% + 50% and 25% + 75%) at the Agronomic Research Area, Department of Agronomy, University of Agriculture, Faisalabad, during 2013-14. The results showed that the crop mixtures and their variable seed ratios showed significant effects on fodder yield and quality traits. The maximum number of tillers, number of leaves plant^{-1}, leaf area, crop growth rate, fresh weight plant^{-1}, dry weight plant^{-1}, green forage yield and dry matter yield were obtained in plots where barley was sown alone at 100% seed ratio. The highest crude fiber and total ash percentage was observed in plots where oat was sown alone at 100% seed ratio and crude protein percentage was highest when oat was blended together with barley at 75% + 25% seed ratios.

Key Words: Wheat; Barley; Oat; Seed Proportions; Forage Yield; Protein Content; Yield; Yield Components; Pakistan.

INTRODUCTION

Cereals are sown throughout the world for forage production for the livestock. Livestock consists 52.2% of agricultural value added products in Pakistan and also contributes 11% to GDP and assist the lives of 30-35 million people in rural areas of the country. At present, there are 176.4 million livestock heads in Pakistan which contributes around 11.9% towards GDP (GoP, 2010). Presently the area under fodder crops is about 3.35 mha out of a total 21.85 million (GoP, 2015). In Pakistan, fodder crops provide 60 mt green fodder per year (GoP, 2015).The animals are usually undernourished due to low quality of fodders produced in Pakistan (Ayub et al., 2004). The scarcity of fodder is a limiting factor in our country because farmers are adopting the conventional system with limited number of cultivars for fodder production.

There is severe shortage of fodder especially during winters and very scarce information to overcome this problem is available to the farmers (Sarwar et al., 2002). Cultivation of various mixtures of different crops is an important trait of sustainable agriculture, and it has gained increasing importance in developed countries also (Wolfe et al., 2008). Successful utilization of blended sowing of crops directly depends on the selection of species with great associative ability (Mapiye et al., 2007). Blended sowing may help in decreasing the gap between requirement and availability of nutrients all around the year (Sarwar et al., 2002).

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Using various seed proportion of a crop in a mixture may affect its time of maturity and increases the dry matter percentage (Juskiw et al., 2000; Alemu et al., 2007). Beneficial effects of mixtures may differ with varying proportion of the component crops in the mixture as the competitive ability among the crops depends on population (Yilmaz et al., 2008). This study was, therefore conducted to explore the quality and production potential of various *rabi* cereals blended in different proportions of seeds.

MATERIALS AND METHOD

The experiment was conducted to evaluate the performance of *rab*i cereals as forage when sown alone and blended together in different seed proportions at the Agronomic Research Area, University of Agriculture, Faisalabad during *rabi* 2013-14.

In the experiment, seeds of wheat, oat and barley (C_1, C_2 and C_3, respectively) were blended together at 100%: 0%, 75% + 25%, 50% + 50% and 25% + 75% seed ratios (SR_1, SR_2, SR_3, SR_4, respectively). Seed ratios of each crop were based on recommended seed rates. The experiment was conducted in randomized complete block design (RCBD) with factorial arrangement with three replications having a net plot size of 2.1m x 7m. Sowing was done with the help of hand drill in 30cm spaced rows. Seedbed was prepared by cultivating the soil 2-3 times with a cultivator upto the depth of 10-12 cm followed by planking with planker. Seeds of all combinations were blended using seed @150 kg ha^{-1} for wheat cultivar Punjab-2011, seed @75 kg ha^{-1} for oat cultivar Avon and seed @ 100 kg ha^{-1} for barley cultivar Soorab-96 were used. Nitrogen, phosphorus and potassium were applied @120, 80 and 60 kg ha^{-1} using urea, diammonium phosphate (DAP) and sulphate of potash (SoP), respectively. One-third of total urea and full dose of DAP and SoP was added at the time of sowing while remaining urea was applied at first and third irrigation. First irrigation was applied 20-25 days after sowing (DAS), 2^{nd} irrigation was applied at booting stage (80-90 DAS) and 3^{rd} irrigation was applied at milking stage (125-130 DAS). All other agronomic practices were kept uniform for all the treatments. Hand weeding was done to eradicate weeds. Harvesting was done manually with a sickle. Weather data (temperature, relative humidity and rainfall) during crop season was also obtained (Figure1).

All the agronomic, forage yield and quality related parameters were recorded following standard procedure. The numbers of plants were counted in square meter of three randomly selected places in each plot and then average of m^{-2} plants was noted. From each plot randomly ten plants were selected and their height was measured from the base to the tip of the plant with measuring tape and then averaged. Total number of leaves from ten plants was counted and then average leaves per plant were calculated. Ten plants from each plot were selected randomly and their leaves were removed and weighed. Then a sub sample of 10g was kept over the screen of leaf area meter (Licor model 3100) to record leaf area. Then this leaf area was used for calculating leaf area per plant. Fresh weight of ten plants from each plot was recorded and then average fresh weight per plant was obtained at

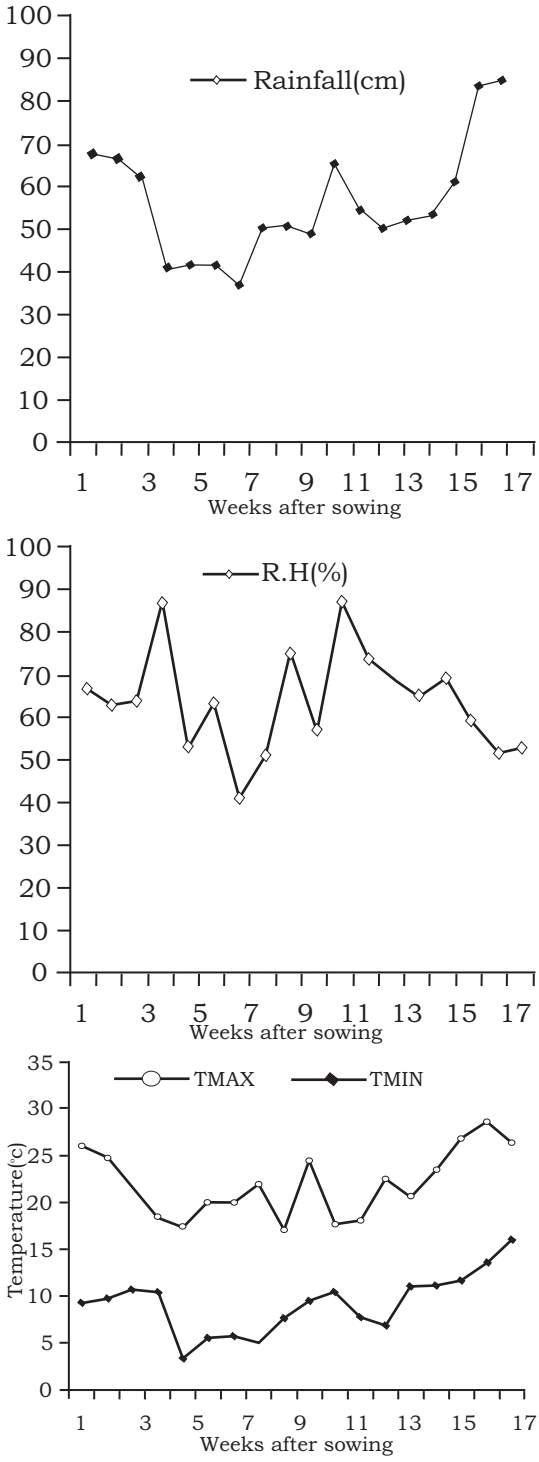

Figure 1. Weekly average temperature, relative humidity and rainfall during crop season

Table 1. Pre-sowing soil mechanical and chemical properties of experimental site

Soil Character	Value (2013-14)
Mechanical analysis	
Sand (%)	62.5
Silt (%)	20.2
Clay (%)	17.3
Soil textural class	Sandy clay loam
Chemical analysis	
EC (dSm^{-1})	1.58
pH	8.1
Organic matter (%)	0.77
Nitrogen (%)	0.042
Available phosphorous (ppm)	7.2
Available potassium (ppm)	119

flowering stage.

Soil sample was analyzed for its various physical and chemical properties (Table 1).

Net assimilation rate (NAR) and crop growth rate (CGR) were estimated by using the formulas proposed by Hunt (1978).

$$NAR = TDM/LAD\ (g\,m^{-2}\,day^{-1})$$
$$CGR = (W_2 - W_1) / (T_2 - T_1)(g\,m^{-2}\,day^{-1})$$

The crude protein (%), crude fiber (%) and total ash percentage was determined by using standard procedure as proposed by AOAC (1984). The data collected from the experiment was statistically analyzed by using Fisher's analysis of variance technique and the difference among the treatment means were compared using least significant difference (LSD) test at 5% probability level (Steel et al., 1997).

RESULTS AND DISCUSSION

Analysis of variance indicated that agronomic, forage yield, quality and traits were significantly different in all the crop combinations at

different seed ratios. The data showed that the maximum leaf area (166.67 cm^2) was recorded from the treatment where oat was sown alone at 100% seed ratio however, minimum value of leaf area (139.33cm^2) was observed in treatment C_2SR_4 where oat+barley were blended together at 25% + 75% seed ratio (Table 2). The maximum value of leaf area index (6.24) was recorded in treatment C_3SR_3 where barley+wheat seed were blended together at 50%+50% seed ratios. The minimum value of leaf area index (3.97) was noted in treatment C_1SR_4 (wheat+oat blended together at 25% + 75% seed ratio).

The maximum crop growth rate (15.44 gm^{-2} d^{-1}) was recorded in treatment C_3SR_1 where barley was sown alone however, the minimum crop growth rate (10.03 gm^{-2} d^{-1}) was observed in treatment C_3SR_3 (barley+wheat blended together at 50% + 50% seed ratio). Maximum NAR (13.13) was observed in treatment C_2SR_4 (oat+barley blended together at 25% + 75% seed ratio) which was statistically at par with the treatments C_3SR_1, C_1SR_2 and C_1SR_3. The minimum net assimilation rate (9.567) was recorded in treatment C_2SR_3 (oat+ barley blended together at 50% + 50% seed ratio (Table 2).

Table 2. Growth and development related traits of cereal crops sown alone and blended together at variable seed ratios

Treatments	Leaf area plant^{-1} (cm^2)	Leaf area index	NAR (g^{-2} day^{-1})	CGR (gm^{-2} day^{-1})	Number of leaves plant^{-1}
C_1SR_1= 100% Wheat	146.33^{def}	4.536^{d}	12.10^{bc}	13.81^{bc}	16.66^{bcd}
C_1SR_2= 75% Wheat + 25% Oat	135.67^{f}	4.28^{de}	12.60^{ab}	12.60^{de}	20.33^{ab}
C_1SR_3= 50% Wheat + 50% Oat	165.33^{ab}	4.84^{def}	12.48^{ab}	11.13^{f}	16^{cd}
C_1SR_4= 25% Wheat +75% Oat	164.67^{ab}	3.97^{f}	10.73^{ef}	12.45^{e}	13.66^{d}
C_2SR_1= 100% Oat	154.33^{bcd}	5.33^{b}	11.30^{cde}	13.62^{c}	18.33^{bc}
C_2SR_2= 75%Oat +25% Barley	163.67^{abc}	4.99^{bcd}	12.35^{ab}	14.62^{ab}	19^{bc}
C_2SR_3= 50%Oat + 50% Barley	140.33^{ef}	4.33^{ef}	9.567^{g}	10.90^{fg}	20.66^{ab}
C_2SR_4= 25%Oat + 75% Barley	139.33^{f}	5.40^{b}	13.13^{a}	13.41^{cd}	15.66^{cd}
C_3SR_1=100% Barley	166.67^{a}	5.19^{bc}	12.60^{ab}	15.44^{a}	23.66^{a}
C_3SR_2=75% Barley + 25% Wheat	140^{ef}	5.10^{bc}	10.10^{fg}	15.67^{a}	20.33^{ab}
C_3SR_3=50% Barley + 50% Wheat	143^{cd}	6.24^{a}	11.20^{de}	10.03^{g}	17^{bcd}
C_3SR_4=25% Barley + 75% Wheat	145^{def}	6.07^{a}	11.86	11.03^{f}	13^{d}
LSD 5%	12.059	0.6106	0.8234	0.9559	4.1756

Means followed by same letter do not differ significantly at P = 0.05 level

Ahmad et al. (2008) in his findings proved that the variation in leaf area and other parameters in different varieties may also be attributed to varying genetic make-up, soil and environmental adaptability of the crops. The higher CGR was obtained from the plots receiving more available nitrogen which subsequently enhances photosynthetic activity (Farrer et al., 2006).

The data showed that maximum number of seedlings (239 m^{-2}) were recorded in treatment C_1SR_3 where wheat + oat were blended together at 50% + 50% seed ratio). It was statistically at par with the treatments C_3SR_1 C_3SR_4 and C_1SR_1 (Table 3). However, lowest numbers of seedlings (137 m^{-2}) were observed in treatment C_2SR_1 in which barley was sown alone at 100% seed ratio followed by the treatments C_2SR_2 and C_1SR_4.Whereas the maximum numbers of tillers (398 m^{-2}) were noted in treatment C_3SR_1. Maximum plant height (137.33 cm) was recorded in treatment C_1SR_4 (wheat+oat blended together at 25% + 75% seed ratio). Maximum fresh weight per plant (18.07 g) was recorded in C_3SR_1 (Table 3) where barley was sown alone however, the result was statistically at par with the treatment C_3SR_2 where barley + wheat were blended together at 75% + 25% seed ratio. The lowest fresh weight per plant (11.33 g) was recorded in treatment C_2SR_2 (oat +

barley blended together at 75% + 25% seed ratio).

Maximum dry weight per plant (8.46 g) was recorded when barley was sown alone and the lowest dry weight per plant (4.63 g) was recorded in treatment C_2SR_4. Maximum dry matter yield (12.16 tha^{-1}) was recorded when barley was sown alone. Minimum dry matter yield (4.70 tha^{-1}) was observed in treatment C_1SR_3 (wheat + oat blended together at 50% + 50% seed ratio). Significantly maximum green forage yield (53.33 t ha^{-1}) was recorded in C_3SR_1 where barley was sown alone at 100% seed ratio. However minimum green forage yield (29.66 t ha^{-1}) was obtained from treatment C_1SR_4 where wheat + oat were blended together at 25% + 75% seed ratio (Table 3).

Dry weight per plant varies with change in component cereal crop (Assefa and Ledin, 2001).These results are in accordance with the findings of (Qamar et al., 2006) who reported that the crop mixtures having barley gave more forage yields than the other blends. The results of green forage yield are in order with the findings of (Giacomini et al., 2003) who concluded that blending with barley seeds gave greater green forage yield than that of other cereal crop. Results support the conclusions drawn by Neumann et al. (2009) who stated that intraspecific competition may be attributed to resource complementarily among the crops. Chemical analysis showed that significantly maximum total ash percentage (13.93%) and crude fiber percentage (29.29%) was recorded from plot C_2SR_1 where oat was sown alone at 100% seed ratio (Table 4). Maximum crude protein (13.1%) was obtained from C_2SR_2 (oat + barley blended together at 75% + 25% seed ratio).The result was contradictory to the findings of Ibrahim et al. (2006) who concluded that crude fiber

Table 3. Forage yield and yield related attributes of cereal crops sown alone and blended together at variable seed ratio

Treatment	Emergence count (m^{-2})	Number of tillers (m^{-2})	Plant height (cm)	Fresh weight $plant^{-1}$(g)	Dry weight $plant^{-1}$ (g)	Green forage yield (t ha^{-1})	Dry matter yield (t ha^{-1})
C_1SR_1= 100% Wheat	222.33^{a}	295.33^{bcd}	81.33^{cde}	12.00^{fg}	5.00^{fg}	30.33^{ef}	8.83^{cde}
C_1SR_2= 75% Wheat + 25% Oat	166.00^{bcd}	238.67^{e}	90.00^{cd}	15.167^{bc}	5.30^{efg}	36.00^{def}	7.30^{def}
C_1SR_3= 50% Wheat + 50% Oat	239.00^{a}	305.67^{bc}	91.00^{c}	12.33^{efg}	5.53^{defg}	35.00^{def}	4.70^{g}
C_1SR_4= 25% Wheat +75% Oat	152.33^{de}	297.33^{bcd}	137.33^{a}	11.63^{fg}	5.96^{cdef}	29.66^{f}	5.88^{fg}
C_2SR_1= 100% Oat	137.00^{e}	307.33^{bc}	125.00^{b}	13.90^{cde}	6.83^{bc}	45.33^{b}	18.33^{bc}
C_2SR_2= 75%Oat +25% Barley	138.67^{e}	288.00^{cd}	75.00^{efg}	11.33^{g}	6.06^{cdef}	49.66^{ab}	6.94^{efg}
C_2SR_3= 50%Oat + 50% Barley	168.33^{bcd}	266.33^{de}	129.00^{ab}	14.433^{cd}	6.30^{cde}	44.00^{bc}	11.20^{ab}
C_2SR_4= 25%Oat + 75% Barley	164.67^{cd}	286.67^{cd}	118.33^{b}	13.46^{cdef}	4.63^{g}	45.66^{b}	6.82^{efg}
C_3SR_1=100% Barley	236.67^{a}	398.00^{a}	68.67^{fg}	18.076^{a}	8.46^{a}	53.33^{a}	12.16^{a}
C_3SR_2=75% Barley + 25%Wheat	191.33^{b}	329.00^{b}	64.67^{g}	16.40^{ab}	7.13^{bc}	37.33^{cde}	9.10^{bcde}
C_3SR_3=50% Barley + 50% Wheat	189.33^{bc}	310.67^{bc}	78.33^{def}	14.57^{bcd}	7.60^{ab}	34.66^{def}	9.53^{bcd}
C_3SR_4=25% Barley +75% Wheat	228.33^{a}	312.67^{bc}	71.00^{efg}	12.90^{defg}	6.70^{bcd}	37.66^{cd}	8.38^{de}
LSD 5%	25.985	38.039	12.066	1.8648	1.2544	7.0908	2.3224

Means followed by same letter do not differ significantly at P = 0.05 level

Table 4. Forage quality parameters of cereal crops sown alone and blended together at variable seed ratios

Treatments	Crude protein (%)	Crude fiber (%)	Total ash (%)
C_1SR_1= 100% Wheat	8.70^{g}	26.56^{c}	11.10^{efg}
C_1SR_2= 75% Wheat + 25% Oat	9.13^{g}	27.20^{c}	12.07^{cd}
C_1SR_3= 50% Wheat + 50% Oat	9.83^{f}	28.03^{b}	13.07^{ab}
C_1SR_4= 25% Wheat +75% Oat	10.06^{ef}	28.43^{ab}	12.80^{bc}
C_2SR_1= 100% Oat	10.86^{d}	29.20^{a}	13.93^{a}
C_2SR_2= 75%Oat +25% Barley	13.10^{a}	27.10^{c}	12.77^{bc}
C_2SR_3= 50%Oat + 50% Barley	11.53^{c}	24.80^{d}	11.63^{de}
C_2SR_4= 25%Oat + 75% Barley	12.00^{bc}	21.40^{f}	10.70^{fgh}
C_3SR_1=100% Barley	12.43^{b}	20.13^{g}	9.90^{h}
C_3SR_2=75% Barley + 25%Wheat	11.73^{c}	21.20^{f}	10.13^{h}
C_3SR_3=50% Barley + 50% Wheat	10.60^{de}	22.90^{e}	10.43^{gh}
C_3SR_4=25% Barley +75% Wheat	9.76^{f}	24.96^{d}	11.33^{def}
LSD 5%	0.5639	0.819	0.8779

Means followed by same letter do not differ significantly at P = 0.05 level

percentage was low in cereals sown alone than in cereal mixtures. Increase in crude protein in mixed sowing at different seed ratios has also been reported by Ahmad et al. (2007) and Ayub et al. (2008).

It is, therefore, concluded that barley when sown alone at 100% seed ratio gave highest forage yield. However oat when sown alone at 100% seed ratio or blended with barley at 75% + 25% seed ratio offered improved quality forage.

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AUTHORSHIP AND CONTRIBUTION DECLARATION

S. No	Author Name	Contribution to the paper
1.	Dr. Muhammad Tahir	Conceived the idea, Overall management of article
2.	Ms. Nawal Zafar	Wrote abstract, Methodology, Did SPSS analysis, Conclusion, Data collection, Data entry in SPSS and analysis, Result and Discussion. Introduction, References

(Received August 2015 and Accepted November 2015)