PERFORMANCE OF WINTER CEREAL-LEGUMES FODDER MIXTURES AND THEIR PURE STAND AT DIFFERENT GROWTH STAGES UNDER RAINFED CONDITIONS OF POTHOWAR

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ABSTRACT

Three cereals viz. oats (*Avena sativa* L.), barley (*Hordeum vulgare*) and wheat (*Triticum aestivum*) were evaluated in pure stands as well as in mixtures of 50: 50 ratios with common vetch (*Vicia sativa* L.) under rainfed conditions of Pothowar to address the problem of nutritious green fodder for livestock. The experiment was sown during second week of October, 2007 in a randomized complete block design at Koont Research Farm, Pir Mehr Ali Shah-Arid Agriculture University, Rawalpindi, Pakistan. The results revealed that oats-vetch mixture performed better at all growth stages under rainfed conditions of Pothowar in terms of green and dry matter yields. By this mixture, 35.06 tons per hectare green fodder and 9.29 ton per hectare dry matter yield was obtained which was 17 and 19 percent higher than oats pure stand, respectively. Similarly, it was calculated that overall oats-vetch mixture yielded 63 and 78 percent higher dry matter than barley-vetch and wheat-vetch, respectively. So oats-vetch mixture can be recommended for higher biomass under rainfed conditions of Pothowar.

KEYWORDS: ***Avena sativa; Hordeum vulgare; Triticum aestivum; Vicia sativa;* mixed cropping; performance; Pakistan.**

INTRODUCTION

Livestock is an important sector of agriculture in Pakistan. It accounts for 49.6 percent of agricultural value addition and about 10.4 percent of GDP. The role of livestock in rural economy may be estimated from the fact that 30-35 millions people of rural areas are engaged in livestock production (with household holdings of 2-3 cattle/buffalo and 5-6 sheep/goat per family) and derive 30-40 percent of their income from it (1). The growth of livestock sector in Pakistan is slower than developed countries. The main reason of this

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slower growth rate in rainfed regions is mostly attributed to non-availability of adequate fodder, which adversely affects the productivity of animals. In recent years, management approaches for feed and fodder production have made it possible to enhance animal performance. Adequate and nutritious fodder has direct effect on animal performance in the form of milk and meet production (12).

Cereals like oats, barley and wheat are the important rabi fodders grown under rainfed conditions of Pothowar for the sustenance of livestock. No doubt these are palatable, succulent and nutritious fodders with sufficient amount of carbohydrate but these are deficient in protein which is necessary for animal health and productivity. Literature also revealed that intake of fodder is low when fed as pure fodders either of legumes or cereals compared with their cereal legume mixtures. Oats form an excellent combination, when fed alongwith other cold seasonal legume crops like berseem, lucerne (alfalfa), senji (Indian clover*),* shaftal (Persian clover) and vetch (*Vicia sativa*). Barley too is winter hardy and potentially promising crop in the annual legume-cereal mixtures for forages and hay product (36). The mixed cropping of vetch with oats, barley and wheat may affect the growth rate of individual species in mixtures as well as forage yield and quality (20). Cereals can provide support for climbing vetches, improve light interception and thus facilitate mechanical harvesting. Incorporation of legume with cereal could be of paramount importance for nutritive value of forage mixture and also to subsequent soil health. Oats, barley, wheat and triticale are added to provide a climbing frame for the legume and to increase the bulk of feed produce (27). Some earlier scientists (3, 17, 31) found that barley- vetch and barley- grass pea rotation yielded more dry matter and crude protein than barley-barley or barley- fallow rotation.

Cereal species, grown with legume mixture components may affect yield and quality of forage produced by mixtures (7, 10, 23). Jesen (16) reported that vetch and wheat together produced higher seed and protein yields than sole cereal as these did not compete each other for nutrient available in soil. Common vetch with oats has been documented most suitable cereal- legume mixture for increased fodder yield (6, 31) whereas in some other studies barley (*Hordeum vulgare* L.) (27) and wheat (*Triticum aestivum* L.) (30) proved as the most suitable cereals for fodder mixtures.

Present study was undertaken to evaluate the effect of cereals and legume as a monoculture as well as in mixtures on yield and yield components of fodder in Pothowar region.

MATERIALS AND METHODS

This study was carried out in the field area of Koont Research Farm, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan located at 33º N and 42.72^{o} E during the winter season 2007-08. Three cereals such as oats (cv. PD_2-LV_{65}), barley (cv. Snober-96) and wheat (cv. Afaq) were tested in pure stand as well as in mixture with legume (vetch cv. Languedock). These crops were sown @ 80, 100, 50 and 45 kg seed per hectare, respectively with single row hand drill at a row spacing of 30 cm. In mixture, seed of component crops were homogenized at 50:50 ratios before sowing. A randomized complete block design was applied with three replications and seven treatments. Nitrogen fertilizer (80 kg/ha) and phosphorous (57 kg/ha) were incorporated before sowing. Plot size of 3×6 meter was used for each treatment and to separate treatments from each other, a buffer zone of 1 meter was provided. Rainfall, temperature, relative humidity and monthly evaporation were also recorded during the crop growth period (Fig. 1 and Fig. 2).

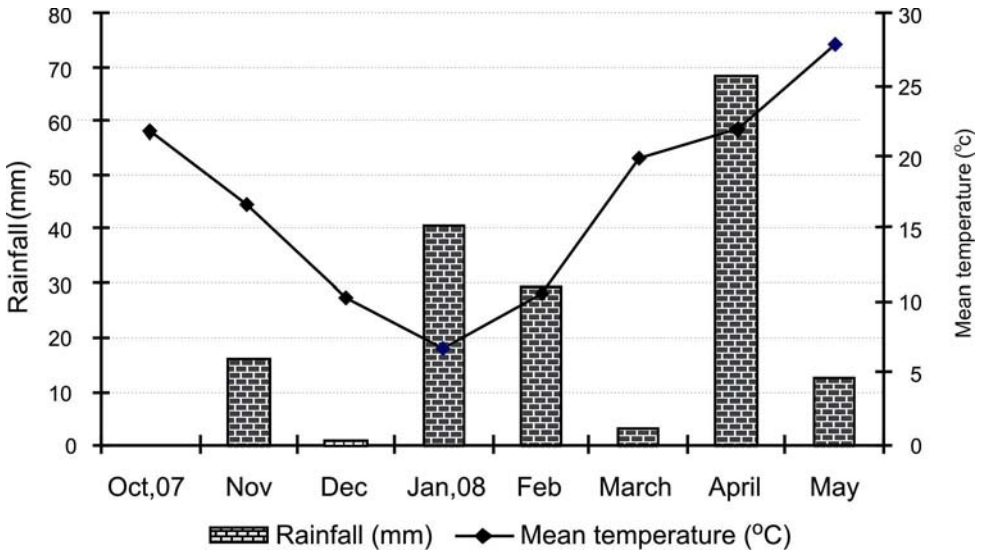

Fig. 1 Rainfall and temperature recorded during the crop growth period.

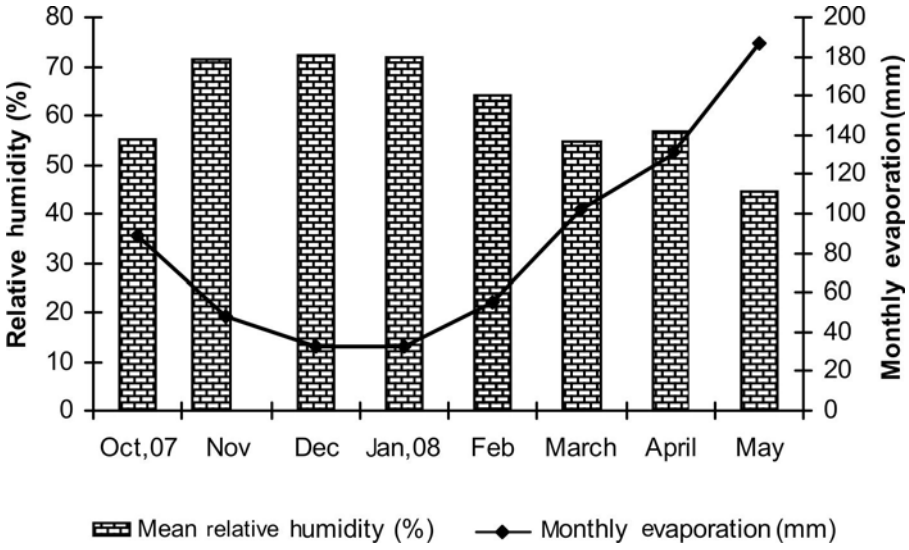

Fig. 2 Relative humidity and monthly evaporation recorded during crop growth period

The plant samples were taken from randomly selected 1m^2 area of each plot at different growth stages i.e. tillering, booting, pre-heading, and 50 percent heading to record fodder yield and yield components. Data regarding plant height, number of leaves per plant, leaf to stem ratio, fresh weight per plant, dry weight per plant, green fodder yield and dry matter yield were recorded. Green fodder and dry fodder yields were determined by harvesting 1 m^2 of each plot by hand. The fodder yield was calculated after drying a sample of 500g fodder in an oven at 78^{0}C for 48 hours. The plant height was measured by averaging the natural standing height of five plants per plot. The results were analyzed by using MSTAT statistical computer package program (2).

RESULTS AND DISCUSSION

Fodder yield components

***Plant height*:** Plant height recorded at different crop growth stages showed significant difference among the treatments (Table 1). In pure stand, maximum plant height (79.75 cm) was attained by oats crop followed by wheat (68.03 cm), barley (66.94 cm) and lowest by vetch (46.30 cm). In mixtures, maximum plant height (82.13 cm) was obtained by oats + vetch mixture followed by barley + vetch mixture (70.23 cm) and wheat + vetch (68.78 cm). The results revealed that plant height in mixture stand is mainly influenced by pure stand of the respective cereal crops. The mixtures of oats + vetch, barley + vetch and wheat + vetch crops obtained 3.62, 4.9 and 2.50 percent more plant height than their respective cereal counterparts

Table 1. Effect of cereal-vetch pure stands and their mixtures on average plant height at different crop growth stages.

Treatments	1st harvest at tillering	2nd harvest at booting	3rd harvest at pre-heading	4th harvest at 50% heading	Means
Oats	32.10 n	51.83 jkl	112.66 cd	122.4 b	79.75 a
Barley	23.86 n	44.26 lm	93.88 ghi	105.75 def	66.94 b
Wheat	28.15 n	48.3b klm	93.22 j	102.4 efg	68.03 b
Vetch	14.81 o	26.08 n	59.15 j	85.33 i	46.30 c
Oats + vetch	25.48 n	54.33 jh	117.33 bc	131.37 a	82.13 a
Barley+vetch	27.03 n	43.08 m	102.44 efg	108.38 de	70.23 b
Wheat+vetch	25.73 n	45.43 lm	97.33 fgh	110.62 cde	68.78 b
Means	25.31 e	44.77 d	96.55 b	109.46 a	

LSD (P=0.05) for treatments mean (T) = 4.286
LSD (P=0.05) for harvest stages (HS) = 3.243
LSD (P=0.05) for T x HS = 8.581

which could be the result of efficient utilization of natural resources and minimum competition between the plants of different species. These results differ with the findings of Turemen *et al.* (32) and Canan and Orak (8) who reported the highest plant height in pure stand. In this study there is possibility that vetch legume may have shared the nitrogen fixed from atmosphere with its respective cereal counterpart crop. Intkhab and Ahmad (15) also described that direct benefits of nitrogen fixation in root nodules of leguminous plant contribute to soil fertility which can be used by companion as well as subsequent crops. Agboola and Fayami (1) reproted an increase in maize grain yield over control when mungbean was interplanted with maize. Similarly, Nnadi and Haque (21) found higher N content in grain from maize that was intercropped with vetch whereas lablab and clover intercrops showed no such effect. It appears that tropical forages legume differ markedly in their ability to benefit associated cereals that have approximately same growing periods. The issue of N transfer from legume to cereal is of great importance and controversial. Two types of beneficial effect have generally been reported: higher nitrogen content and/ or higher grain yield of intercropped cereals in comparison with cereal alone without any added nitrogen. Several investigators (14, 35) found no specific effect of cereal or grass on the release of N from actively growing roots. Some workers Eaglesham (11) and Reynolds (25) have reported higher N contents and uptake in mixtures compared with sole cropping system.

Number of leaves per plant

The results (Table 2) revealed that number of leaves was higher (41.59) in vetch crop in pure stand at all successive harvests followed by barley, wheat and oats. However, leaf area was low vetch crop because of low developed in crop canopy which ultimately intercepted less radiation. Gurmani *et al.* (13)

concluded that less green fodder yield is the result of less number of leaves, less plant height and leaf length. Among mixtures barley-vetch produced more number of leaves (26.99) because barley showed more number of leaves and tillers than other cereal crops in comparison. Minimum leaf number (15.60) was recorded in wheat + vetch mixture.

Table 2. Effect of cereal-vetch pure stands and their mixtures on average number of leaves per plant at different crop growth stages.

Treatments	1st harvest at tillering	2nd harvest at booting	3rd harvest at pre-heading	4th harvest at 50% heading	Means
Oats	7.73 o	22.53 efghi	19.55 ghijkl	18.1 hijklm	16.98 d
Barley	13.4 mno	26.4 de	23.33 efgh	19.43 ghilklm	20.64 c
Wheat	8.4 o	24.33 efg	21.66 efghijk	17.22 ijklm	17.91 cd
Vetch	16.3 jklm	52.23 a	53.53 a	44.32 b	41.59 a
Oat + vetch	9.93 no	19.06 ghijklm	22.21 efghijk	21.10 efghijk	18.08 cd
Barley+ vetch	14.53 lmn	35.66 c	31.98 cd	25.78 ef	26.99 b
Wheat+vetch	8.13 o	15.64 klmn	20.11fghijkl	18.54 ghijklm	15.60 d
Means	11.21 c	27.98 a	27.48 a	23.50 b	

LSD (P=0.05) for treatments mean (T) = 3.040
LSD (P=0.05) for harvest stages (HS) = 2.298
LSD (P=0.05) for T x HS = 6.080

Number of tillers/branches per plant

The results (Table 3) clearly indicated significant difference for number of tillers/branches per plant among treatments. In pure stand, maximum number of tillers/branches was produced by vetch (7.20) followed by barley (5.18), oats (4.38) and wheat (3.50) on the basis of mean of growth harvests. However, early growth stages (tillering and booting appeared in January and February, respectively) no significant difference was observed between wheat and oats. With the advancement of growth stages i.e. pre-heading (March) and 50 percent heading (April), there was significant difference in number of tillers between oats and wheat. This shows that oats crop responded more to increased temperature than wheat crop.

In mixtures, consistently higher number of tillers / branches was recorded in barley + vetch mixture at all successive crop growth stages followed by oats + vetch and wheat + vetch. It was due to more number of tillers/branches in both individual crops throughout the study period. Orak *et al*. (22) also reported higher number of tillers/branches and seed per plant in barley + vetch mixture while Canan and Orak (9) reported higher number of branches/tillers in oats + vetch mixture.

Table 3. Effect of cereals-vetch pure stands and their mixtures on average number of tillers/branches per plant at different crop growth stages.

Treatments	1st harvest at tillering	2nd harvest at booting	3rd harvest at pre-heading	4th harvest at 50% heading	Means
Oats	2.3 jk	4.7 efghi	5.5 ab	5.1 b	4.38 d
Barley	3.5 bc	5.6 bc	6.0 bcde	5.5 cde	5.18 c
Wheat	2.2jk	4.6 efghi	3.9 fghi	3.4 ijk	3.50 e
Vetch	5.6 cde	8.7 a	7.4 ab	7.1 bc	7.20 a
Oats + vetch	3.3 ijk	5.1 defg	5.5 cde	5.4 def	4.85 cd
Barley+vetch	4.5 efghi	7.5 ab	7.1 bc	6.3 bcd	6.36 b
Wheat+vetch	2.0 k	3.6 ghij	3.9 fghi	3.6 ghij	3.28 e
Means	3.36 b	5.71 a	5.60 a	5.18 a	

LSD (P=0.05) for treatments mean (T) = 0.589
LSD (P=0.05) for harvest stages (HS) = 0.779
LSD (P=0.05) for T x HS = 1.560

Leaf stem ratio

Leaf stem ratio represents the leaf weight divided by stem weight. In pure stand, mean maximum leaf stem ratio was recorded in oats (1.08) followed by barley (0.76) and wheat (0.68) (Table 4). Leaf stem ratio in crops decreased with the advancement of crop growth stage and increase in stem thickness. In mixtures, maximum leaf stem ratio was noted in oats + vetch (0.85) followed by barley + vetch (0.73) mixture. The higher leaf stem ratio of oats + vetch mixture is the result of greater leaf weight and area in oats crop.

Table 4. Effect of cereals-vetch pure stands and their mixtures on average leaf stem ratio recorded at different crop growth stages.

Treatments	1st harvest at tillering	2nd harvest at booting	3rd harvest at pre-heading	4th harvest at 50% heading	Means
Oats	1.9 a	1.2 de	0.7 fghi	0.53 ghilj	1.08 a
Barley	1.5 b	0.9 ef	0.3 j	0.26 j	0.76 bc
Wheat	1.2 cde	0.8 fg	0.4 ij	0.33 j	0.68 c
Vetch	0.7fgh	0.5 hij	0.5 hij	0.33 j	0.48 d
Oats + vetch	1.4 bcd	1.2 de	0.4 hij	0.38 ij	0.85 b
Barley + vetch	1.5 bc	0.8 f	0.3 j	0.26 j	0.73 bc
Wheat +vetch	1.2 de	0.8 f	0.3 j	0.25 j	0.63 cd
Means	1.36 a	0.90 b	0.39 c	0.34 c	

LSD (P=0.05) for treatments mean (T) = 0.153
LSD (P=0.05) for harvest stages (HS) = 0.115
LSD (P=0.05) for T x HS = 0.306

Green fodder yield

Significant differences were also observed in green fodder yield recorded at different crop growth stages. In pure stand, there is no significant difference among the treatment means at early growth stages but later in the season, oats crop produced higher green fodder yield than all other sole crops in comparison. These results are similar to those of Canan and Orak (9) who recorded higher herbage yield in oats and lower in vetch in pure stands. In green fodder yield recorded from pure stands of crops at different crop growth stages. Oats crop (31.58 t/ha) ranked first followed by barley (23.54 t) and wheat (20.01 t). The overall growth rate in all crops remain slower during December and January while it was faster from February to April with increased temperature and availability of moisture due to occurrence of rainfall during February.

Table 5. Effect of cereals-vetch pure stands and their mixtures on green fodder yield (t/ha) recorded at different crop growth stages.

Treatments	1st harvest at tillering	2nd harvest at booting	3rd harvest at pre-heading	4th harvest at 50% heading	Means
Oats	5.73 klm	12.32 jk	49.00 c	59.26 c	31.58 b
Barley	5.50 klm	11.54 jkl	35.66 efg	41.45 cde	23.54 cd
Wheat	6.15 jklm	7.85 jklm	31.33 gh	34.7 efg	20.03 de
Vetch	2.29 m	5.12 klm	22.33 i	25.3 hi	13.76 f
Oats + vetch	4.11 lm	11.49 jkl	65.13 ab	71.15 a	37.97 a
Barley+vetch	6.39 jklm	13.47 j	33.33 fg	44.32 cd	24.38 c
Wheat+vetch	4.57 lm	7.38 jklm	22.33 i	39.38 def	18.42 a
Means	4.96 d	9.88 c	37.02 b	45.08 a	

LSD (P=0.05) for treatments mean (T) = 3.842
LSD (P=0.05) for harvest stages (HS) = 2.907
LSD (P=0.05) for T x HS = 7.691

The highest green fodder yield (37.97 t/ha) was obtained in oats + vetch mixture followed by barley + vetch (24.38t). Canan and Orak (9) also reported that mixtures were more productive than pure vetch sowing. They also quoted in another place that maximum herbage yield was obtained from mixture of vetch (25%) and oats (75%) and minimum from pure stand of vetch. In early growth stages i.e. 1st harvest December and 2nd harvest January, barley + vetch mixture produced higher green fodder yield (6.39 and 13.47 t/ha) followed by oats + vetch and wheat + vetch mixture. The higher green fodder yield in early growth stages seems to be the result of more number of tillers per plant.

Dry matter yield

The data (Table-6) indicated a dry matter yield trend similar to green fodder yield. In pure stands, maximum dry matter yield was obtained by oats crop (7.75 t/ha) followed by barley and wheat. In mixtures, oats + vetch ranked first (9.28 t) even in all successive harvests followed by barley + vetch (5.69 t) and wheat + vetch (5.22 t).

Table 6. Effect of cereals-vetch pure stands and their mixtures on dry matter yield (t/ha) recorded at different crop growth stages.

Treatments	1st harvest at tillering	2nd harvest at booting	3rd harvest at pre-heading	4th harvest at 50% heading	Means
Oats	0.97 lmn	1.75 l	13.42 c	15.23 b	7.75 b
Barley	0.94 lmn	1.66 lm	8.44 ghi	9.64 ef	5.17 d
Wheat	0.87 lmn	1.46 lm	7.73 ij	8.74 gh	4.70 e
Vetch	0.55 n	0.83 mn	7.11 j	7.71 ij	4.04 f
Oats + vetch	1.23 lmn	3.31 k	15.18 b	17.42 a	9.28 a
Barley+vetch	0.96 lmn	1.71 l	9.23 fg	10.87 d	5.69 c
Wheat+vetch	0.91 lmn	1.57 lm	8.12 hi	10.31 de	5.22 d
Means	0.92 d	1.76 c	9.88 b	11.42 a	

LSD (P=0.05) for treatments mean (T) = 0.438
LSD (P=0.05) for harvest stages (HS) = 0.331
LSD (P=0.05) for T x HS = 0.877

They further mentioned that as seed rate of vetch in mixture increased, herbage and dry matter yields decreased. The present results also revealed that mixtures gave higher yields than the pure sowings. Similar results have been reported earlier (2, 5, 24).

CONCLUSION

The study concludes that the highest green fodder and dry matter yields were obtained from oats-vetch mixture under rainfed conditions of Pothowar. In pure stands maximum green fodder yield was recorded in oats crop followed by barley, wheat and vetch. Fodder yield increased with advancement of growth stage and it was maximum at 50 percent heading. However, it is added that vetch has little resprouting ability therefore its harvesting is discouraged at early growth stage.

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