PERFORMANCE OF NON-TRADITIONAL WINTER LEGUMES WITH OATS FOR FORAGE YIELD UNDER RAINFED CONDITIONS

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ABSTRACT

Performance of monoculture and mixed cropping of non-traditional legumes with oats cereal was evaluated at National Agricultural Research Centre, Islamabad, Pakistan under rainfed conditions of Pothowar. Three non-traditional winter legumes i.e. common vetch (*Vicia sativa* L.), medics (*Medicago polymorpha* L.) and senji (*Melilotus indica* L.) were sown during first week of November, 2007 at recommended seed rates in pure stands and ratio of 50:50 of each in mixed cropping with oats (*Avena sativa* L.). The experiment was laid out in RCBD with three replications and plot size was 6 x 3 m^2. Nitrogen fertilizer @ 80 kg and phosphorus @ 57 kg per hectare were incorporated in soil at the time of seedbed preparation. The results revealed that oats - vetch mixture produced 16 and 18 percent higher green fodder yield compared with oats - medics and oats - senji mixtures, respectively. In pure stands maximum green fodder yield was obtained from oats crop which was 51, 66 and 80 percent higher than vetch, medics and senji legumes, respectively. This increase in green fodder yield of oats cereal is the result of more efficient utilization of natural resources by Poaceae family plants than the Fabaceae family producing more tillers, number of leaves and plant height. The analysis of soil after final harvest showed more organic matter in vetch plots followed by oats - vetch mixture and lowest in pure oats crop. This showed opposite response of plants belonging to Poaceae and Fabaceae families indicating the need of mixed cropping of these plants to harvest the higher biomass and maintain soil fertility.

KEYWORDS: ***Vicia sativa; Avena sativa; Medicago polymorpha; Melilotus indica;*** **performance; rainfed farming; mixed cropping, Pakistan.**

INTRODUCTION

Livestock is an integral part of rainfed farming system in Pakistan. Livestock population has increased by about 29 percent during the year 1996 to 2006 but area under fodder crops has decreased by 8.07 percent during this period

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(1) resulting in severe scarcity of green fodder for existing livestock population. Farmers usually grow wheat, brassica, oats and barley crops as green fodder for winter feeding for their livestock under rainfed conditions (22). These crops provide sufficient amount of carbohydrates but are deficient in protein to fulfil body as well as productivity requirements of the animals. There is severe shortage of nutritionally balanced green fodder during winter months due to low rainfall and thus livestock has to depend on wheat straw, dry stalks of maize, sorghum and millet. Oats crop provides an excellent choice to obtain higher green fodder yield among winter cereals and can be grown both under irrigated and rainfed conditions (13). It is also broadly adaptable cereal crop on marginal lands with nutrient-poor, low rainfall and cool temperatures (3).

In view of animal as well as soil health, there is no legume fodder crop to be incorporated in cropping system during winter season under rainfed conditions. The two major winter legume fodder crops such as berseem and alfalfa are confined only to irrigated areas of the country (22). Forage legumes have significant role in agriculture and are often integrated in mixed farming systems to enhance crop yields through their nitrogen fixing ability as well as their use for high quality feed for intensive livestock systems (5).

Vetch, medics and senji are very good pasture crops during winter months and being the leguminous, these crops have the potential to improve soil fertility through biological nitrogen fixation and provide nutritive fodder. These can be grown to produce nutritious fodder, hay, grain or green manure while providing the rotational benefits (17). Benefits of mixtures include greater uptake of water and nutrients, enhanced weed suppression, and increased soil conservation (21). Similarly, when grown in rotation with small grain cereals, common vetch can provide off-season forage to cover forage deficiency, and can provide additional benefits to soil quality and subsequent cereal crops (15). The incorporation of legumes in intercropping system significantly increased the crude protein (10). Intercropping of cereals with forage legumes has improved both quantity and quality of fodder, which subsequently improved the livestock production considerably (20). Cereal-legume forages alone were evaluated for milk and beef production. The results revealed that insufficient intakes of organic matter and crude protein limited the animal performance (9, 20).

The present study was carried out to evaluate the performance of non-traditional legumes with and without oats to ensure the supply of nutritional fodder for livestock under rainfed conditions of Pothowar and its subsequent effect on soil health.

MATERIALS AND METHODS

This study was conducted at National Agricultural Research Centre, Islamabad, Pakistan during 2007. Three non-traditional winter legumes i.e. common vetch *(Vicia sativa* L.), medics *(Medicago polymorpha* L.) and senji *(Melilotus indica* L.) were sown in pure stands and in combination with cereal oats. Nitrogen and P_2O_S fertilizer @ 80 and 57 kg per hectare, respectively in the form of urea and DAP were applied at the time of seedbed preparation. Oats, vetch, senji and medics were sown as monoculture as well as in mixture. The seed rate for pure oats was 80 kg and for pure senji, medics, and vetch was 45 kg per hectare each. Seed rate for mixture of oats- senji, oats-medics and oats-vetch was in ratio of 50:50. The experiment comprising seven treatments was sown with single row hand drill in 30 cm spaced rows and plot size of 3 x 6 m^2 on November 7,2007 in RCBD. In mixture, seed of both crops was thoroughly mixed before sowing.

An area of 1 m^2 from each plot was harvested at tillering (60 DAS), booting (90 DAS), pre-heading (120 DAS) and 50 percent heading stage (150 DAS) to determine green fodder and dry matter yields. Ten plants were taken randomly from each plot to record morphological characteristics viz. plant height, number of leaves per plant, number of tillers/branches per plant, etc. Soil samples were collected before sowing of crop and analyzed. After harvest (May 10, 2008) of crop soil samples were again collected to evaluate the effect of cereal-legume and their mixture on soil fertility and other physico-chemical properties of experimental site. The data were analyzed for analysis of variance using MSTAT-C software (2). To compare the significance of means, least significance difference test at 5 percent probability level was employed (18). Weather data recorded during the crop season are presented in Table-1.

Table 1. Meteorological data recorded during the crop growth period.

Month	Rainfall (mm)	Mean maximum temperature (^oC)	Mean minimum temperature (^oC)	Mean temperature (^oC)	Mean relative humidity (%)	Monthly evaporation (mm)
October, 07	0.0	30.1	13.7	21.9	63.4	126.7
November	8.0	25.3	8.73	17.01	68.0	62.8
December	0.0	18.9	4.2	11.5	62.0	44.9
January, 08	80.0	14.1	2.5	8.45	66.8	48.5
February	35.0	18.5	5.2	11.8	63.8	75.2
March	5.0	28.5	13.1	20.8	54.6	152.5
April	90.0	28.8	17.6	23.2	55.7	182.7
May	15.0	35.3	24.0	29.6	40.1	238.9

RESULTS AND DISCUSSION

Green fodder yield

Significant differences were observed for green fodder yield in intercrops at different growth stages (Table 2). Among mixtures the highest and statistically significant green fodder yield was recorded in oats-vetch mixture (30.59 t/ha) followed by oats-medics (25.8 t/ha) and lowest (25.14 t/ha) in oats-senji mixture. In mixtures of oats- medics and oats-senji, forage yield was lower by 19 and 22 percent, respectively than that in oats vetch. In monoculture, statistically significant yield was obtained in oats (27.56 t/ha) followed by vetch (13.45 t/ha). Data recorded at different crop growth stages showed that statistically significant green fodder yield (37.77 t/ha) was obtained at 50 percent heading stage followed by pre- heading stage (33.63 t/ha). Green fodder yield was minimum at tillering stage (2.94 t/ha). Similar results were reported by Hussain *et al.* (7) who recorded higher forage yield at 50 percent flowering stage of oats. Lower biomass obtained in all the crops during winter could be due to slower growth rate in January-February. However, it increased with faster rate from March to April with increase of temperature and availability of moisture from rainfalls received during early spring.

Table 2. Green fodder yield (t/ha) recorded from pure stands of non- traditional legumes and their mixtures with oats at different crop growth stages.

Treatments	Tillering	Booting	Pre-heading	50% heading	Mean
Oats	4.88 lm	6.17 jkl	47.01 cd	52.2 ab	27.56 b
Senji	0.084 o	0.24 o	9.3l j	12.5 i	5.53 f
Medics	0.51 no	0.73 no	17.29 h	19.36 gh	9.47 e
Vetch	1.87 mno	3.24 lmno	22.16 g	26.53 f	13.45 d
Oats - senji	3.92 lmno	4.68 lm	43 e	48.96 bc	25.14 c
Oats - medics	4.13 lmn	5.79 jkl	43.89 de	49.4 bc	25.80 bc
Oats - vetch	5.20 klm	9.02 ijk	52.75 ab	55.4 a	30.59 a
Mean	2.94 c	4.27 c	33.63 b	37.77 a	

LSD (P=0.05) for treatments mean (T) = 1.939
LSD (P=0.05) for harvest stages (HS) = 1.465
LSD (P=0.05) for T x HS = 3.877

Oats-vetch mixture at 50 percent heading and at pre-heading stage produced green fodder yield similar to oats produced at 50 percent heading stage. Although fodder yield both in mixture and sole stand is same yet substantial effect of mixture crop proved much beneficial for soil health in view of increased prices of fertilizers than pure cereal crop (Table 7). It was recorded from the data that at different crop growth stages legume - cereal mixture produced more green fodder as well as dry matter yield than their respective pure stands (Table 2 and 3). Similar findings were recorded by Canan and Orak (4) who reported the highest herbage yield from oats-vetch mixture than

their pure stands. Similarly, Lowe (12) obtained higher forage yield from cereal - legume (oats-vetch and oats-pea) mixtures. Lithourgidis *et al.* (11) observed better compatibility of medics with oats and rye grass for dry matter yields and seasonal distribution than all other mixtures tested in the study.

Dry matter yield

Statistically significant and higher dry matter yield was recorded in oats-vetch mixture (8.69 t/ha) followed by oats - senji (6.36 t/ha) and oats-medics (6.31 t/ha) which were statistically at par with each other (Table 3). In mono-culture, the highest dry matter yield was obtained by oats (7.56 t/ha) followed by vetch (3.86 t/ha) and medics (2.96 t/ha). The data indicated that dry matter yield had similar trend as was observed in green fodder yield. Among harvesting stages, there is significant difference of dry matter yield at each growth stage. Maximum dry matter yield was recorded at 50 percent heading stage (10.5 t/ha) followed by pre- heading stage (9.04 t/ha) against the lowest at tillering stage (0.64 t). Similar results have been reported by Canan and Orak (4) who obtained the highest dry matter yield in oats-vetch mixture. They further observed that as the seed rate of vetch in mixture increased, the herbage and dry matter yields decreased. Similar results have also been reported by Raubert *et al.* (16).

Table 3. Dry matter yield (t/ha) recorded from pure stands of non-traditional legumes and their mixtures with oats at different crop growth stages.

Treatments	Tillering	Booting	Pre-heading	50% heading	Mean
Oats	1.07 ijkl	1.67 ij	12.96 c	14.53 b	7.56 b
Senji	0.02 m	0.08 lm	3.39 h	3.85 h	1.84 f
Medics	0.11 lm	0.26 klm	5.35 g	6.12 fg	2.96 e
Vetch	0.47 klm	0.71 jklm	6.53 f	7.74 e	3.86 d
Oats - senji	0.79 ijklm	1.5 ij	10.82 d	12.34 c	6.36 c
Oats - medics	0.87 ijklm	1.8 i	9.88 d	12.68 c	6.31 c
Oats - vetch	1.14 ijk	3.07 h	14.33 b	16.23 a	8.69 a
Mean	0.64 d	1.3 c	9.04 b	10.5 a	
LSD (P=0.05) for treatments (T)	= 0.511				
LSD (P=0.05) for harvest stage (HS)	= 0.386				
LSD (P=0.05) for T x HS	= 1.022				

Fodder yield components

Statistically significant differences were observed among treatments mean of number of tillers per plant (Table 4). In mixtures treatment, mean maximum number of tillers/branches (7.45) was recorded in oats-vetch mixture followed by oats-senji (6.90). Statistically significant interactions were also recorded among treatment means at different growth stages. The highest number of

tillers/branches was recorded at pre-heading stage (14.03) in vetch crop followed by same at booting (12.83) and 50 percent heading (12.1). In sole crops, vetch produced statistically higher branches (11.17) followed by oats (6.59) and medics (3.27). These results are in line with earlier findings (4, 14).

Table 4. Number of tillers/branches recorded from pure stands of non-traditional legumes and their mixtures with oats at different crop growth stages.

Treatment	Tillering	Booting	Pre-heading	50% heading	Mean
Oats	2.63 klm	7.8 cdef	8.43 cd	7.5 cdef	6.59 c
Senji	2.93 jklm	1.7 m	1.96 lm	1.6 m	2.05 f
Medics	3.61 ijk	3.06 ijklm	3.33 ijkl	3.1 ijklm	3.27 e
Vetch	5.73 gh	12.83 ab	14.03 a	12.1 b	11.17 a
Oats - senji	4.43 hij	7.7 cdef	8.2 cde	7.3 def	6.90 bc
Oats - medics	4.35 hij	6.46 fg	6.8 efg	5.4 gh	5.75 d
Oats - vetch	4.5 hi	8.53 cd	8.96 c	7.8 cdef	7.45 b
Means	4.02 c	6.87 ab	7.39 a	6.4 b	
LSD (P=0.05) for treatments (T)		= 0.770			
LSD (P=0.05) for harvest stage (HS)		= 0.582			
LSD (P=0.05) for T x HS		= 1.542			

Statistically significant differences were also recorded for plant height (Table 5). Maximum plant height (67.72 cm) was recorded in oats pure stand followed by oats-vetch mixture (59.73 cm). The results revealed that plant height in mixture is a result of mutual benefit of cereal/legume components for each other. In mixtures, companion cereals provided structural support for common vetch growth, improved light interception, and facilitated mechanical harvest, whereas common vetch in mixtures improved the plant height and quality of forage as was witnessed by other researchers (19). Gurmani *et al.* (6) concluded that less green fodder yield was the result of less plant height. Among different crop growth stages, maximum plant height was recorded at 50 percent heading stage (67.43 cm) which led to maximum biomass production. With regards to interaction oats crop attained maximum plant height (96.8 cm) at 50 percent heading followed by oats at pre heading stage (95.23 cm). Among intercrops oats-vetch attained maximum plant height (94.6 cm) at 50 percent heading (Table 5).

Table 5. Plant height (cm) recorded from pure stands of non-traditional legumes and their mixtures with oats at different crop growth stages.

Treatments	Tillering	Booting	Pre-heading	50% heading	Mean
Oats	32.78 h	46.1 f	95.23 a	96.8 a	67.72 a

Senji	5.1 m	6.63 m	23.23i j	23.8 j	14.69 g
Medics	6.25 m	9.18 lm	38.43 g	41.5 fg	23.84 f
Vetch	13.66 kl	22.13 j	86.6 c	88.4 bc	52.69 c
Oats - senji	16.21 k	24 ij	58.53 e	61.2 de	39.98 e
Oats - medics	23.93 ij	25.83 ij	63.53 de	65.7 d	44.75 d
Oats - vetch	24.06 ij	27.36 l	92.9 ab	94.6 a	59.73 b
Mean	17.43 c	23.04 b	65.50 a	67.43 a	

LSD (P=0.05) for treatments (T) = 2.558
LSD (P=0.05) for harvest stage (HS) = 1.934
LSD (P=0.05) for T x HS = 5.117

Table 6. Soil analysis data of experimental site after the harvest of crop.

Treatments	Organic matter %	EC (ds/m)	Available P (mg/kg)	Available K (mg/kg)
Oats	1.33	0.32	10.21	69.67
Senji	1.45	0.30	8.80	73.72
Medics	1.58	0.29	10.32	71.37
Vetch	2.15	0.25	14.06	79.79
Oats - senji	1.64	0.28	12.41	72.16
Oats - medics	1.69	0.31	13.75	69.77
Oats - vetch	1.91	0.27	14.13	81.33
Mean	1.68	0.29	11.95	73.97

Soil analysis recorded after the harvest of each plot showed that vetch pure stand produced maximum organic matter (2.15%) followed by oats - vetch mixture (1.91 %) and lowest (1.33 %) in oats pure stand (Table 6). The analysis of soil also predicted the highest availability of P and K in oats-vetch mixture and lowest in oats crop while the response of EC is vice versa. Intkhab and Ahamd (8) also concluded that legumes have direct benefit of nitrogen fixation through root nodules to enhance soil fertility which can be used for companion as well as subsequent crops.

CONCLUSION

The study concludes that the highest green fodder and dry matter yields were obtained from oats-vetch mixture followed by pure stand of oats. In addition to increased biomass, oats-vetch mixture also increased the soil fertility which may certainly minimize the cost of heavy fertilizer inputs for poor farmers of the Pothowar region. The results also revealed that fodder yield increased with the advancement of growth stage and maximum green fodder yield was obtained at 50 percent heading.

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