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PRODUCTION POTENTIAL OF FODDER OAT (*Avena sativa* L.) BASED CROPPING SEQUENCES WITH DIFFERENT SOURCES OF NITROGEN UNDER TEMPERATE CLIMATIC CONDITIONS OF KASHMIR

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ABSTRACT

Field experiments were carried out at Cattle Research Station, SKUAST-K, Manasbal, India to find optimum nitrogen source for higher fodder production of good quality in two cropping sequences during 2007-08 and 2008-09. The cropping sequence of oat-maize-turnip recorded higher fresh fodder production, dry matter accumulation and crude protein productivity as compared to oat-sorghum cropping sequence. The magnitude of increase with oat-maize-turnip sequence in above respective parameters was 24.40, 6.64 and 9.32% over oat-sorghum cropping sequence. Integrated approach (50% N through organic and 50% N through inorganic source) proved better than the supply of nitrogen through organic source only. The supply of nitrogen through integrated approach recorded 22.28, 20.00 and 17.70% superiority in fresh fodder production, dry matter accumulation and protein productivity, respectively, over the supply of nitrogen through organic source only. Further, supply of 50% nitrogen through sheep manure and 50% through urea proved 25.80, 23.45, 22.0, 11.97 and 1.39% superior in fresh fodder production over the supply of nitrogen through sheep manure or farm yard manure (FYM) or vermicompost or 50% N as vermicompost + 50% as urea or 50% N as FYM + 50% as urea, respectively.

Key words: Cropping sequence, crude protein, fodder, oat, nitrogen sources

INTRODUCTION

The animal productivity, besides other factors, depends upon the availability and quality of feed and fodders. The fodder production in India is insufficient to meet the requirements of growing livestock population and the country faces a net deficit of 61.1% in green fodder, 21.9% in dry crop residues and 64% in feeds (Agarwal *et al*., 2008). The shortage of feed and fodder has resulted in low productivity of Indian livestock (Tripathi *et al.,* 2009). The fodder-based feeding strategies are cheaper as they reduce the cost of quality livestock products. It has been postulated that fodders are 5-14 times cheaper sources of digestible crude protein and total digestible nutrients than concentrates (Agarwal *et al*., 2008).

In Jammu & Kashmir State, livestock sector is a promising and potential area. The grazing in J&K State is restricted to subalpine and alpine pastures. Out of 11.2 lakh ha gross cultivated area in the State 4.8% area is under cultivated fodder crops (Anonymous, 2005). However, the production from the area does not suffice the requirements of 10 million livestock population of the State which faces a net deficit of 25% in roughages. Fodder cultivation is equally or more remunerative than grain, cash or commercial crops (Agarwal *et al.*, 2008). In order to increase the quality fodder production for better and sustained animal productivity and profitability, the evaluation of different fodder-based cropping sequences in Kashmir valley is of paramount importance. Further, nitrogen being the primary nutrient plays an important role in the growth and development of plants and is an essential constituent of proteins, enzymes, nucleic acids, chlorophyll, etc. To apply nitrogen for higher fodder production and profitability, different available sources of nitrogen need to be evaluated under the existing climatic conditions. The present investigation was, therefore, undertaken to study the production potential of two fodder oat (*Avena sativa* L.) based cropping sequences with different nitrogen sources under temperate conditions of Kashmir.

MATERIALS AND METHODS

Field experiments were conducted during years 2007-08 and 2008-09 at Cattle Research Station, Manasbal, SKUAST, Kashmir. The experimental soil was clay loam in texture, neutral in reaction (pH, 7.2), high in organic carbon (2.4%), medium in available phosphorus (19.6 kg ha^{-1}) and available potassium (432 kg ha^{-1}) and low in available nitrogen (178 kg ha^{-1}). Two cropping sequences viz., oat (*rabi*) - maize (*rabi*) - turnip (*kharif*) (C_1) and oat (*rabi*) - sorghum (*rabi*) (C_2) in main plot and six different combinations of nitrogen sources viz., 100 kg N ha^{-1} through organic source i.e. farm yard manure [FYM] (F_1) or sheep manure (F_2) or vermicompost (F_3) and application of 50 kg N ha^{-1} through inorganic source (urea) + 50 kg N ha^{-1} through organic sources, viz., FYM (F_4) or sheep manure (F_5) or vermicompost (F_6) in sub-plot were tested in split plot design with three replications. Oat cv. 'Sabzar' was sown with row to row spacing of 25 cm, whereas maize cv. 'African tall' and sorghum cv. 'MP Chari' were sown at a spacing of 40 cm. The experiment was conducted under assured irrigation system and need-based irrigation was applied to fodder crops.

The nitrogen content in FYM, sheep manure and vermicompost was estimated on dry weight basis and simultaneously moisture content was also calculated. Subsequently nitrogen requirement as per treatments was estimated. The manures were applied 10 days before sowing twice in a year viz., to *rabi* oat and *kharif* maize - sorghum as per the treatments during both the years. The nitrogen through urea was applied in two split doses as per the treatments, half as basal dose and rest at 15 cm height to oat crop and knee height to maize and sorghum crops. No nitrogen in any form was applied to turnip fodder crop. The P_2O_5 @ 60 kg ha^{-1} and K_2O @ 20 kg ha^{-1} were applied to each fodder crop in sequence during both the years. The phosphorus was supplied through single super-phosphate and potassium through muriate of potash. The plant samples were taken at harvest time for the estimation of dry matter and nitrogen contents. The crude protein content was calculated by multiplying nitrogen content with 6.25 and subsequently the protein productivity was calculated by taking the crude protein content of dry matter. Oat and sorghum were harvested at 50% flowering stage while maize at 50% silking stage. The fodder turnip was harvested 60 days after sowing. Cost of cultivation and gross returns were computed on the basis of prevailing market price of inputs and outputs. For computation of net returns, cost of cultivation of each treatment was subtracted from the gross returns received from the treatments and B:C ratio worked out by dividing gross returns with cost of cultivation. The data was statistically analyzed by using Minitab software package for windows. Statistically significant differences were measured by analysis of variance and LSD ($P<0.05$) was used to compare the means.

RESULTS AND DISCUSSION

Phenology: Fodder oat crop took 188 to 206 days to reach 50% flowering whereas fodder maize crop took 34-35 and 80-82 days to attain knee height stage and 50% silking stage, respectively. The fodder sorghum took 47-49 and 124-126 days to reach knee height and 50% flowering, respectively. The variation to reach different phenological stages might be due to the difference in G x E interaction of oat, maize and sorghum crops.

Fresh fodder yield, dry matter and crude protein: The cropping sequences and different sources of nitrogen exhibited significant influence on fresh fodder yield, dry matter production and crude protein productivity. The oat-maize-turnip cropping sequence recorded significantly higher fresh fodder yield and dry matter accumulation than oat-sorghum. The magnitude of increase in fresh fodder production and dry matter accumulation with oat-maize-turnip sequence was 24.40 and 6.64% over oat-sorghum cropping sequence, respectively (Table 2). Variation in fodder yield and protein productivity among the different cropping sequences has also been reported by Singh *et al.* (2007).

In general, nitrogen applied through integrated approach (50% as organic and 50% as inorganic) gave significantly higher mean fresh fodder yield and dry matter accumulation than the nitrogen supplied only through organic source. It may presumably be due to the better synchrony between nitrogen supply and crop demand in integrated approach than the supply of nitrogen through organic source only. Among the organic sources, sheep manure and FYM proved superior to vermicompost. Among the sources of nitrogen F_5 (50 kg N ha^{-1} through sheep manure and 50 kg N ha^{-1} through urea) recorded significantly higher mean fodder yield and dry matter accumulation than F_1, F_2, F_3 and F_6, however it was at par with F_4. In turn, F_2 recorded significantly higher fodder yield and dry matter production than F_1, F_2, F_3 and $F_{6;}$ whereas F_6 proved superior over F_1, F_4 and F_2; and the difference was non-significant among F_1, F_2 and F_3. The supply of nitrogen in the form of 50% as sheep manure and 50% as urea showed 25.8, 23.45, 22.0, 11.97 and 1.39% yield superiority in terms of fresh fodder production than the supply of whole nitrogen as sheep manure only or FYM only or vermicompost only or 50% N as vermicompost + 50% as urea, or 50% N as FYM + 50% as urea, respectively. These results may be attributed to the better synchrony between nitrogen supply and crop demand in integrated approach than supplying nitrogen only through organic source. Poor synchrony between soil nitrogen supply and crop demand has also reported by Fageria and Baligar (2005).

Table 1: Green fodder yield, dry matter production and crude protein content as influenced by different cropping sequences and nitrogen sources

Treatments	Fodder yield (t ha^{-1})			Dry matter (t ha^{-1})			Crude protein (t ha^{-1})		
	2008	2009	Mean	2008	2009	Mean	2008	2009	Mean
Cropping sequences									
C_1 (Oat-maize-turnip)	96.46	94.83	95.64	25.16	24.27	24.71	14.80	14.1	14.53
C_2 (Oat-sorghum)	77.12	76.65	76.88	23.32	23.02	23.17	13.00	13.0	13.29
S.Em$\pm$	2.02	2.54	2.12	0.47	0.27	0.37	0.17	0.13	0.14
$CD_{0.05}$	7.72	9.72	8.51	1.75	0.81	1.22	0.63	0.41	0.46
Source of nitrogen									
F_1 (100 kg N ha^{-1} through FYM)	71.03	81.20	76.15	20.15	22.97	21.56	10.70	13.9	12.35
F_2 (100 kg N ha^{-1} as sheep manure)	72.78	76.70	74.78	20.97	21.44	21.20	12.60	13.0	12.85
F_3 (100 kg N ha^{-1} as vermicompost)	77.03	77.01	77.01	21.60	21.87	21.73	13.40	13.0	13.27
F_4 (50 kg N ha^{-1} as urea + 50 kg N ha^{-1} as FYM)	94.49	90.90	92.72	27.40	25.56	26.48	15.20	15.0	15.16
F_5 (50 kg N ha^{-1} as urea + 50 kg N ha^{-1} as sheep manure)	96.36	91.67	94.01	27.85	25.86	26.85	14.90	14.6	14.79
F_6 (50 kg N ha^{-1} as urea+ 50 kg N ha^{-1} as vermicompost)	85.85	82.67	84.26	24.92	23.40	24.16	15.40	15.1	15.32
S.Em$\pm$	2.34	2.18	2.12	0.54	0.21	0.31	0.19	0.16	0.17
$CD_{0.05}$	7.06	6.58	6.24	1.58	0.63	1.01	0.58	0.52	0.56

Table 2: Relative economics (Rs. ha^{-1}) of various treatment combinations

Treatment (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})			Cost of cultivation (Rs. ha^{-1})			Net profit (Rs. ha^{-1})			B:C ratio		
	2008	2009	Mean	2008	2009	Mean	2008	2009	Mean	2008	2009	Mean
C_1F_1	168852	180075	174464	102810	102810	102810	66042	77265	71654	1.64	1.75	1.70
C_1F_2	172491	174668	173579	73350	73350	73350	99141	101318	100229	2.35	2.38	2.37
C_1F_3	163380	140010	151695	188550	188550	188550	-25170	-48540	-36855	0.87	0.74	0.80
C_1F_4	202956	210795	206876	74460	74460	74460	128496	136335	132416	2.73	2.83	2.78
C_1F_5	229164	211910	220537	59730	59730	59730	169434	152180	160807	3.84	3.55	3.69
C_1F_6	185430	179355	182393	116550	116550	116550	68880	62805	65843	1.59	1.54	1.56
C_2F_1	91395	105840	98618	92950	92950	92950	-1555	12890	5668	0.98	1.14	1.06
C_2F_2	100035	100748	100391	63490	63490	63490	36545	37258	36901	1.58	1.59	1.58
C_2F_3	114249	117203	115726	178690	178690	178690	-64441	-61488	-62964	0.64	0.66	0.65
C_2F_4	119751	123795	121773	64600	64600	64600	55151	59195	57173	1.85	1.92	1.89
C_2F_5	117765	117368	117566	49870	49870	49870	67895	67498	67696	2.36	2.35	2.36
C_2F_6	132762	119535	126149	106690	106690	106690	26072	12845	19459	1.24	1.12	1.18

Input: Maize seed = Rs 30 kg^{-1}; sorghum seed = Rs.25 kg^{-1}; oat seed = Rs.16 kg^{-1}; turnip seed = Rs. 200 kg^{-1}; sheep manure = Rs. 1.5 kg^{-1}; FYM = Rs. 1.2 kg^{-1}; vermicompost = Rs. 6.0 kg^{-1}; N = Rs 11.95 kg^{-1}; P_2O_5 = Rs. 24.0 kg^{-1}; K_2O = Rs. 9.0 kg^{-1}; labour @ Rs110 day^{-1}

Output**:** Green fodder = Rs 1.5 kg^{-1}; turnip fodder = Rs 3.0 kg^{-1}

Treatments: C_1= Oat (*rabi*) **-** maize (*rabi*) **-** turnip (*kharif*) cropping sequence; C_2 = Oat (*rabi*) **-** sorghum (*rabi*) cropping sequence; F_1 = Farm yard manure [FYM] @ 100 kg N ha^{-1}; F_2 = Sheep manure @ 100 kg N ha^{-1}; F_3 = Vermicompost @ 100 kg N ha^{-1}; F_4 = Urea @ 50 kg N ha^{-1} + FYM @ 50 kg N ha^{-1}; F_5 = Urea @ 50 kg N ha^{-1} + sheep manure @ 50 kg N ha^{-1}; F_4 = Urea @ 50 kg N ha^{-1} + vermicompost @ 50 kg N ha^{-1}

The oat-maize-turnip cropping sequence recorded significantly higher mean crude protein productivity as compared to oat-sorghum cropping sequence. The magnitude of increase in crude protein productivity with oat-maize-turnip sequence was 9.32% over oat-sorghum cropping sequence. The higher protein productivity may be attributed to higher dry matter production under oat-maize-turnip cropping sequence. Among the nitrogen sources the integrated approach of nitrogen application was superior to the application of nitrogen only through organics with respect to crude protein productivity. The highest mean crude protein productivity was observed in the treatment 50 kg N ha^{-1} through vermicompost + 50 kg N ha^{-1} through urea, which was at par with treatments F_4 and $F_{5;}$ but statistically superior to F_1, F_2 and F_3. The F_3 produced significantly higher crude protein productivity than F_1 and F_2, however F_1 and F_2 were at par (Table 1). These results reveal better synchrony between N supply and crop demand in integrated approach strategy.

Residual effect: The application of nitrogen through FYM and sheep manure recorded higher fresh fodder yield and dry matter accumulation during 2009 over the year 2008. However, application of nitrogen through integrated approach (50% through organics and 50% through inorganic) registered higher fresh fodder yield and dry matter accumulation during 2008 than 2009, indicating that the supply of nitrogen through organic source only has substantial residual effect over the years which was reflected in terms of fresh fodder yield and dry matter accumulation (Table 1). The residual effect of different organic fertilizers has been reported by Kumpawat (2010).

Relative economics: The nitrogen source F_5 (50 kg N ha^{-1} through sheep manure + 50 kg N ha^{-1} through urea) recorded higher mean gross return (Rs. 22,0537 ha^{-1}), mean net profit (Rs. 1,60,807 ha^{-1}) and B:C ratio (3.69) in all oat based cropping sequences than other nitrogen sources (Table 2). Further, the highest mean gross return net profit and B:C was observed in treatment 50% nitrogen through sheep manure + 50% through urea under oat-maize-turnip cropping sequence followed by C_1F_4, C_1F_2, C_2F_4

and C_1F_1. Treatments C_1F_3 and C_2F_3 showed negative net profit. These results may be ascribed to the higher fodder production by treatment 50% nitrogen through sheep manure + 50% through urea under oat-maize-turnip cropping sequence and the higher cost of vermicompost as compared to sheep manure and FYM (Table 2).

Conclusion: The study revealed that cropping sequence oat-maize-turnip has higher fodder and protein production potential. The integrated approach of nitrogen application (50% through organics and 50% through inorganic) was better than the application of nitrogen through organic source only. In integrated approach sheep manure and FYM were equal in supplying the nitrogen to crops. However, the application of 50% nitrogen through sheep manure + 50% through urea under oat-maize-turnip cropping sequence was economically better than other treatment combinations. Therefore, cropping sequence oat-maize-turnip may be recommended for low lying areas of Kashmir.

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