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EFFECT OF NITROGEN LEVELS, ORGANIC MANURES AND *AZOTOBACTER* INOCULATION ON YIELD AND ECONOMICS OF MULTI-CUT OATS

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SUMMARY

A field experiment was conducted at Research Farm, CCSHAU, Hisar, laid out in split-plot design with treatments comprising four nitrogen (0, 40, 80 and 120 kg N/ha) and two bio-fertilizers (no inoculation and inoculation with *Azotobacter chrococcum*) levels in main plots and five levels of organic manures (control, FYM @ 5 t/ha, FYM @ 10 t/ha, vermicompost @ 5 t/ha and vermicompost @ 10 t/ha) in sub-plots, replicated thrice. Application of nitrogen levels significantly improved green fodder yields at fodder harvest (75 DAS), yield attributes, grain and straw yields and net returns up to 80 kg N/ha. Inoculation of oats seed with *Azotobacter* improved significantly the green fodder yield, yield attributes, grain and straw yields and economic returns of oats during both the years. Among five levels of organic manures, application of vermicompost @ 10 t/ha resulted in maximum green fodder yield, yield attributes, grain and straw yields and economic returns which were statistically at par recorded in FYM @ 10 t/ha. *Azotobacter* inoculation had pronounced effect under no nitrogen or at lower levels of nitrogen than higher levels of nitrogen during both the years of experimentation.

Key words : Oats, nitrogen, *Azotobacter*, oraganic manures, fodder yield, grain yield, economics

India supports nearly 20% of the world's livestock being the leader in cattle (16%) and buffalo (5.5%) population. Deficiency in feed and fodder has been identified as one of the major components in achieving the desired level of livestock production (Kumar *et al*., 2012). Oats (*Avena sativa* L.) is the most important cereal (graminaceous) forage crop grown during winter season, which is fed in the form of green and dry fodder as well as silage. Taking one cut for fodder and grain production from regrowth, improves the economics of multi-cut fodder oats cultivation. Growth of plant is directly related to the nutrient supply and if it is in the integrated form, it adds more to growth. Being a fast growing and high yielding crop, oats require a large quantity of fertilizer nitrogen for enhancing production of quality herbage. However, low priority of fodder crops, increasing cost and nitrate toxicity in early crop growth stage due to application of high dose of nitrogenous fertilizer and soil and water pollution in the long run, often restrict N fertilizer use in oats production. Hence, a judicious combination of chemical fertilizers, organic manures and biofertilizers can be of vital importance in order to achieve optimum and economic yield of fodder oats. INM directly enhances the nutrient uptake with better accumulation in grains (Devi *et al*., 2009). Apart from improved varieties and irrigation, balanced fertilization is critical for realizing higher yield. Keeping in view the scanty information available on these aspects of multi-cut oats, the investigation was carried out.

MATERIALS AND METHODS

Field experiment was conducted at Research Farm of CCS Haryana Agricultural University, Hisar during 2003-04 and 2004-05. The experiment was laid

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out in split-plot design comprising four nitrogen (0, 40, 80 and 120 kg N/ha) and two bio-fertilizers (no inoculation and inoculation with *Azotobacter chrococcum*) levels in main plots and five levels of organic manures (control, FYM @ 5 t/ha, FYM @ 10 t/ha, vermicompost @ 5 t/ha and vermicompost @ 10 t/ha) in sub-plots, replicated thrice. The experimental soil was sandy loam in texture, low in available nitrogen (163 kg/ha) and phosphorus (8.4 kg/ha), medium in available potassium (329 kg/ha) and normal in reaction (pH 7.85). Oats variety HJ-8 as seeding materials, farm yard manure and vermicompost as organic manure sources, urea (46% N) and DAP (18% N and 46% P_2O_5) as fertilizers and *Azotobacter* culture for inoculation were used as experimental materials during both the years.

Chemical composition of farm yard manure and vermicompost (oven dry weight basis)

Components	Farm yard manure (%)		Vermicompost (%)	
	2003-04	2004-05	2003-04	2004-05
Nitrogen	0.60	0.64	1.30	1.25
Phosphorus	0.22	0.25	0.32	0.30
Potassium	0.60	0.60	0.62	0.60

Inoculation of seed with *Azotobacter chrococcum* was done as per recommended method and sowing was done by *kera* method in rows 30 cm apart with seed rate of 100 kg/ha. One third dose of nitrogen was applied at sowing and second split was applied at 45 DAS. Green fodder yield was recorded by harvesting the oats 75 DAS and samples were dried at 60°C till constant weight was achieved to record dry matter yield. After taking one fodder cut at 75 DAS, third split of nitrogen was applied and oat crop was remanaged for seed production. Data on yield attributes as well as grain and straw yield were recorded at harvest of the seed crop. The economics of different treatments was calculated based on prevailing prices of the inputs and produce. Data were analyzed by following the standard procedure for ANOVA (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

Green Fodder Yield at 75 DAS

Increasing levels of nitrogen up to 80 kg/ha significantly increased the green fodder yield at 75 DAS, which was statistically at par with 120 kg/ha during both the years (Table 1 and Fig. 1). However, highest green fodder yield was achieved at 120 kg N/ha. Application of nitrogen resulted in increased proportion of protoplasm of cell wall material which caused an increase in the size of cell, ultimately increased growth parameters (Devi *et al*., 2009), resulting in increase in green fodder yield. Increase in fodder yield with increase in nitrogen levels was also reported by Hasan and Shah (2000), Sharma *et al.* (2002), Sharma (2009) and Dubey *et al.* (2013).

Green fodder yield increased significantly with the *Azotobacter* inoculation as compared to no inoculation during both the years (Table 1). The *Azotobacter* helped in fixation of more atmospheric nitrogen than non-inoculated treatment, providing direct additional nitrogen nutrition and, therefore, resulted in increased crop growth (Devi *et al*., 2009), which increased the green fodder yield.

Application of different organic manures did not affect the green fodder yield significantly in both the years (Table 1). However, highest green fodder yield was recorded with application of vermicompost @ 10 t/ha followed by FYM @ 10 t/ha. This increase in growth parameters of oats due to organic manures might be attributed to increased supply of major and micro nutrients and increase in the activities of heterotrophic bacteria and fungi in soil, which in turn increased the activity of enzymes responsible for conversion of unavailable form of nutrients to available form leading to higher nutrient uptake and improvement in crop growth parameters (Devi *et al*., 2009).

Interaction effects between nitrogen levels and biofertilizer inoculation on green fodder yield at fodder harvest in both the years were significant (Table 2 and Fig. 1). The green fodder yield increased significantly with inoculation under control and lower level of nitrogen

TABLE 1
Effect of nitrogen levels, *Azotobacter* and organic manures on fodder yield, yield attributes, yield and harvest index of multi-cut oats

Treatment	Green fodder yield (kg/ha)		Panicles/ m.r.l.		Panicle length (cm)		Grains/ panicle		1000-grain wt. (g)		Grain yield (q/ha)		Straw yield (q/ha)		Harvest index (%)	
	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr	1st yr	2nd yr
Nitrogen levels																
Control	124.71	150.72	49.51	48.50	32.72	33.30	63.10	68.34	31.77	31.30	8.25	9.15	38.40	38.33	17.68	19.27
40 kg/ha	134.07	165.37	52.92	50.95	33.68	35.84	68.31	73.74	34.39	33.70	11.65	12.35	41.26	40.83	22.01	23.22
80 kg/ha	222.51	228.54	57.73	60.66	37.40	40.84	71.57	83.53	35.99	35.08	19.31	20.40	60.64	70.68	24.15	22.39
120 kg/ha	225.93	231.99	59.00	61.90	38.02	41.42	72.77	84.57	36.42	36.68	19.79	20.81	61.34	71.71	24.39	22.49
C. D. (P=0.05)	16.51	11.82	2.15	2.26	2.79	1.94	2.19	3.51	0.82	1.71	2.21	2.47	1.73	9.54	0.24	NS
Biofertilizers																
No inoculation	162.59	179.59	52.88	52.94	34.94	36.12	67.20	74.29	34.22	33.67	10.16	11.22	45.12	51.40	29.67	32.77
Azotobacter inoculation	191.02	208.72	56.69	58.06	35.97	39.57	70.67	80.80	35.06	34.75	12.75	13.76	60.79	65.76	35.67	38.80
C. D. (P=0.05)	11.67	1.36	1.52	1.59	NS	1.37	1.55	2.48	0.58	NS	1.72	1.84	1.22	6.75	3.25	3.47
Organic manures																
Control	145.81	165.90	49.19	49.90	32.25	35.47	63.20	70.45	32.50	32.70	8.72	9.13	43.67	49.12	16.64	15.67
5 t/ha FYM	173.30	188.55	53.37	54.32	36.14	36.70	67.85	75.13	34.05	33.73	11.65	12.25	50.50	51.77	18.74	19.13
10 t/ha FYM	193.41	212.72	57.86	58.63	36.69	39.36	71.69	81.31	35.99	35.25	18.21	19.47	53.60	57.42	25.35	25.32
5 t/ha vermicompost	175.80	187.65	54.42	54.90	34.83	37.56	68.75	76.92	34.20	33.95	12.89	12.93	51.41	55.93	20.04	18.77
10 t/ha vermicompost	195.71	215.95	59.10	59.75	37.36	40.15	73.20	83.90	36.46	35.41	19.01	20.21	54.39	60.60	25.89	25.00
C. D. (P=0.05)	NS	NS	2.57	NS	NS	NS	NS	NS	NS	NS	2.01	2.36	1.44	1.58	0.39	NS

NS–Not Significant.

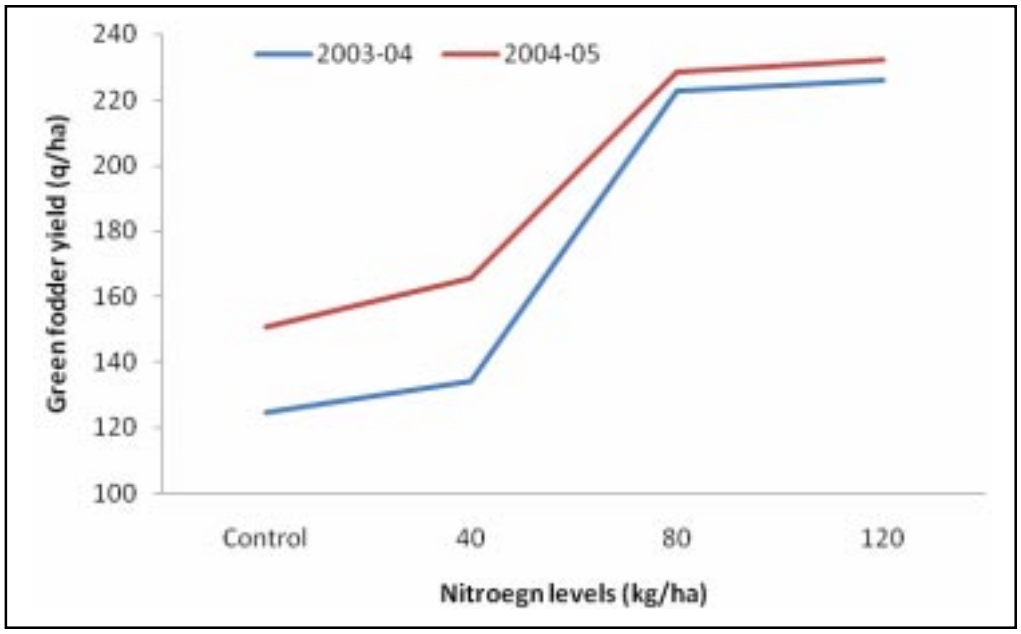

Fig. 1. Effect of nitrogen levels on green fodder yield at 75 DAS of oats.

i. e. 40 kg/ha, but not at higher levels of nitrogen. Improvement in growth of oats due to interaction of nitrogen levels and *Azotobacter* inoculation was also reported by Sheoran *et al.* (2000).

Yield Attributes

All the yield attributing characters viz., number of panicles, panicle length, grains per panicle and 1000-grain weight significantly improved by each successive increase in nitrogen level during both the years (Table 1). The response of nitrogen was, however, significant up to 80 kg/ha and further increase in nitrogen dose of 120 kg/ha failed to cause an appreciable increase in yield attributes.

Increasing level of fertilizers in growth medium increased the quantity of carbohydrates that is assimilated by the panicle alone or translocated from other parts to the developing kernel in the panicle, which produced greater number of grains and other yield attributes also increased with increasing level of nitrogen. Corroborative findings were reported by Sharma and Bhunia (2001), Patel and Rajgopal (2002) and May *et al.* (2004).

Inoculation with *Azotobacter* brought significant improvement in effective panicles per metre row length during both the years, panicle length during second year, grains per panicle during both the years and 1000-grain weight during first year, whereas panicle length during first year (2003-04) and 1000-grain weight during second year remained unaffected (Table 1). Favourable effects of inoculation may be ascribed to increased availability of nitrogen to plants and by fixing atmospheric nitrogen by bacterial strain, which helped in higher uptake of nutrients and enhanced physiological processes that in turn caused rapid cell division and cell elongation, increasing all yield components (Tomar *et al.*, 1995). Similar results were reported by Sheoran *et al.* (2000).

Various yield attributing characters i. e. panicle number per metre row length, panicle length, grains per panicle and 1000-grain weight were not affected significantly with application of organic manures during both the years except number of panicles per metre row length during first year (Table 1). Numerically all the characters increased with increasing level of organic manures, but not at the significant rate.

Highest number of panicles, maximum length of panicle, number of grains per panicle and 1000-grain weight were achieved with higher level (10 t/ha) of organic manures which showed superiority to lower levels (5 t/ha) and control. Significant improvement in yield attributing characters in wheat by application of organic manures was also observed by Minhas *et al.* (1995), Rathore *et al.* (1995) and Ranwa and Singh (1999).

Grain and Straw Yield

Application of both 80 and 120 kg N/ha levels

produced significantly higher grain and straw yields than 40 kg N/ha and control (Table 1 and Fig. 2). However, both the two N levels were statistically at par with respect to grain yield. The higher grain and straw yields obtained with increasing nitrogen levels could be ascribed to the favourable effect on yield attributing characters i. e. panicles/metre row length, panicle length and grains/ panicle. The grain yield equivalent also increased with successive increase in nitrogen levels up to 80 kg N/ha and highest was recorded at 120 kg N/ha, which was at par with 80 kg N/ha. Higher grain yield with successive increase in N application was also reported by Joon *et al.* (1993), Sharma and Bhunia (2001), Sharma *et al.* (2002) and Rana *et al.* (2002). Increase in green and dry forage yields with increase in nitrogen levels was also reported by Kumar *et al.* (2001), Agarwal *et al.* (2002), Kakol *et al.* (2003) and Mahale *et al.* (2003).

The inoculation of oats seed with *Azotobacter* brought about a significant increase in grain yield as compared to non-inoculated treatment during both the

TABLE 2
Interaction effect of nitrogen and *Azotobacter* on green fodder and grain yield (q/ha) of oats

Treatment	Nitrogen levels (kg/ha)				
	N_0	N_{40}	N_{80}	N_{120}	C. D. (P=0.05)
Green fodder yield at 75 DAS (q/ha)			**1st year**		
Uninoculated	111.09	123.26	205.62	210.41	23.35
Azotobacter inoculation	138.34	144.89	239.41	241.45	
			2nd year		
Uninoculated	127.96	149.28	218.06	223.08	
Azotobacter inoculation	173.49	181.46	239.02	240.90	6.72
Grain yield (q/ha)			**1st year**		
Uninoculated	7.21	10.61	18.73	19.30	
Azotobacter inoculation	9.29	12.64	19.89	20.40	2.23
			2nd year		
Uninoculated	7.53	10.99	18.5	19.10	
Azotobacter inoculation	9.36	12.71	19.85	20.20	2.44

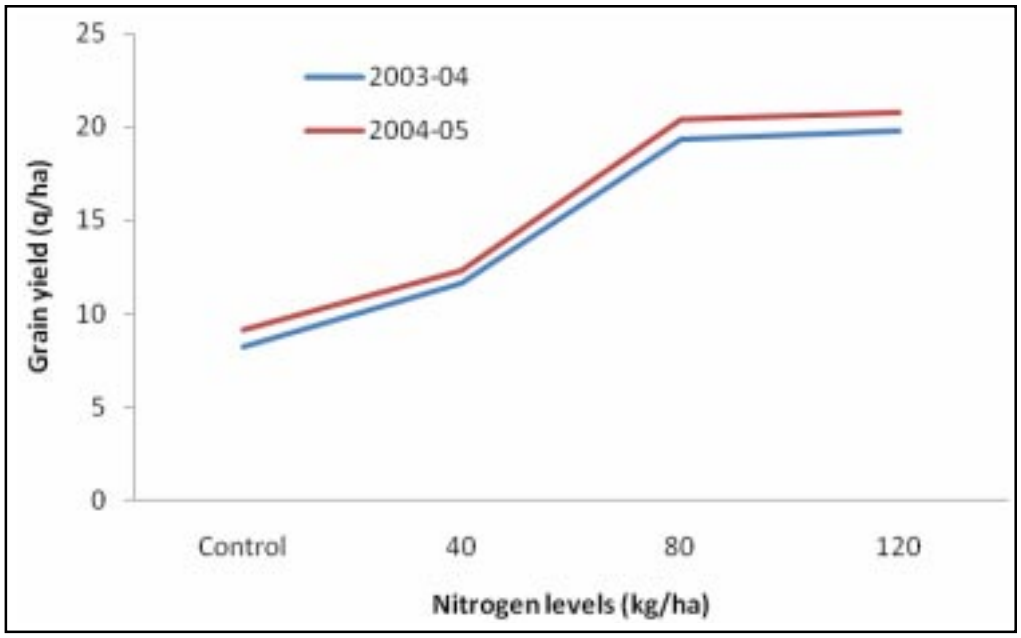

Fig. 2. Effect of nitrogen levels on grain yield at 75 DAS of oats.

years (Table 1). The higher yield under bacterial strain inoculation might be due to build up of their higher population in soil at different growth stages viz., a week after sowing, tillering and flowering which in turn helped in fixation of more atmospheric nitrogen over non-inoculated treatments. These findings are in conformity with the results of Rawat and Hazra (1997), Desale *et al.* (1999), Sheoran *et al.* (2002), Agarwal *et al.* (2002), Mahale *et al.* (2003) and Mahale *et al.* (2004).

The grain and straw yields increased significantly with the application of organic manures over no organic manure during both the years (Table 1). Significantly higher yields were recorded with the application of vermicompost @ 10 t/ha over other organic manures and statistically was at par with FYM @ 10 t/ha. The beneficial effects of organic manures on yield might be attributed to the fact that after proper decomposition and mineralization of organic manures due to rise in temperature at later stages of crop growth of winter season, the organic manures supplied available plant nutrients directly to the plants and also had solubilising effect on fixed forms of nutrients (Raghuwanshi and Umat, 1994). In addition to supply of nutrients, organic manure application improved the physical, chemical and biological properties of soil to produce higher yields (Ganai and Singh, 1988). Further, the use of FYM mobilizes the unavailable nutrients present in the soil system (Cooke, 1967). Bhatia *et al*. (2012) also reported increase in grain and straw yield of wheat with integration of organic manures with fertilizers. The organic manures also increased the adsorptive power of soil for cations and anions particularly phosphates and nitrates and these adsorbed ions are released slowly for the benefit of crop during entire crop growth period leading to higher yields (Singh *et al.*, 1981). Though organic manure could not improve yield attributes up to the level of significance, but they were increased numerically and additive effect of these improved yield attributes resulted in significant increase in grain and straw yields.

The interaction effects of nitrogen levels and *Azotobacter* inoculation on grain yield were significant during both the years (Table 2). Grain yield was increased significantly with inoculation under control and lower level of nitrogen i. e. 40 kg/ha, but not at higher levels of nitrogen. Grain yield equivalent was also influenced by different organic manures and was recorded maximum with application of vermicompost @ 10 t/ha followed by application of FYM @ 10 t/ha. Improvement in growth of oats due to interaction of nitrogen levels and *Azotobacter* inoculation was also reported by Sheoran *et al.* (2000).

Harvest Index (%)

The application of nitrogen at different levels significantly influenced the harvest index only during the first year and not during the second year (Table 1). Maximum harvest index was recorded with 120 kg N/ha during both the years. Inoculation with *Azotobacter* did not affect the harvest index significantly during both the years (Table 1). This might be on account of almost similar pattern of increase in grain and straw yields under the inoculation treatment. Application of organic manures significantly influenced the harvest index only during the first year of experiment. The harvest index was maximum with vermicompost @ 10 t/ha.

Economics

The grain yield equivalent was increased with successive increase in nitrogen levels up to 80 kg N/ha and highest was recorded at 120 kg N/ha, which was statistically at par with 80 kg N/ha (Table 3). The *Azotobacter* inoculation increased the grain yield equivalent over uninoculated crop during both the years of experimentation. Grain yield equivalent was influenced by different organic manures and was recorded maximum with vermicompost at 10 t/ha followed by FYM @ 10 t/ha.

The application of nitrogen @ 80 and 120 kg/ha increased gross returns and net returns of oats crop as compared to 40 kg/ha level (Table 3). However, the differences between the two levels (80 and 120 kg/ha) in respect of all the economic parameters were very small. The increase in net return with the application of 80 and 120 kg N/ha was Rs. 9190 and 9215/ha during first year and Rs. 8125 and 8120/ha, respectively, during second year as compared to 40 kg/ha. *Azotobacter* inoculation gave higher gross and net returns during both the years than uninoculated treatment. The net returns were Rs. 3275 and 3255 higher with *Azotobacter* inoculation during both the years, respectively (Table 3). Application of organic manure increased the gross and net returns during both the years. They increased with increasing levels of organic manures and were maximum with application of vermicompost @ 10 t/ha, which was comparable to application of FYM @ 10 t/ha. Sharma (2009) also reported higher gross and net

TABLE 3
Effect of nitrogen, *Azotobacter* and organic manures on economics of multi-cut oats

Treatment	Grain yield equivalent (q/ha)		Cost of cultivation (Rs./ha)	Gross returns (Rs./ha)		Net returns (Rs./ha)	
	1st yr	2nd yr		1st yr	2nd yr	1st yr	2nd yr
Nitrogen levels							
Control	25.13	29.14	10460	12565	14570	2105	4110
40 kg/ha	29.79	34.23	10894	14895	17115	4001	6221
80 kg/ha	49.04	51.35	11329	24520	25675	13191	14346
120 kg/ha	49.96	52.21	11764	24980	26105	13216	14341
C. D. (P=0.05)	-	-	-	-	-	-	-
Biofertilizers							
No inoculation	31.92	35.34	10460	15960	17670	5500	7210
Azotobacter inoculation	38.70	42.08	10575	19350	21040	8775	10465
C. D. (P=0.05)	-	-	-	-	-	-	-
Organic manures							
Control	28.39	31.48	10460	14195	15740	3735	5280
5 t/ha FYM	34.96	37.45	10700	17480	18725	6780	8025
10 t/ha FYM	44.08	47.86	10940	22040	23930	11100	12990
5 t/ha vermicompost	36.55	38.23	10940	18275	19115	7335	8175
10 t/ha vermicompost	45.20	49.15	11420	22600	24575	11180	13155
C. D. (P=0.05)	-	-	-	-	-	-	-

returns with higher dose of nitrogen, *Azotobacter* inoculation and organic manures as compared to their controls.

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