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Research Paper

Effect of integrated nitrogen management on transplanted pearlmillet (*Pennisetum glaucum*) under rainfed condition

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ABSTRACT

A field experiment was conducted during *kharif* seasons of 2006 and 2007 to evaluate the effect of integrated nitrogen management on performance of pearlmillet {*Pennisetum glaucum* (L.) R. Br. Emend. Stutz} under rainfed conditions. Integrated nitrogen management (INM), significantly increased the growth parameters *viz*., plant height, dry matter production, effective tillers per plant and chlorophyll content and yield attributes and yield *viz.* weight of grains per ear head, test weight, grain, stover and biological yields and harvest index as compared to control. Among the INM treatments applications of 50% RDN through FYM + 50% through urea and 80% RDN through vermicompost + 20% through urea being at par were found superior over 100% RDN through urea, 100% RDN through FYM, 75% RDN through FYM + 25% through urea and 25% RDN through FYM + 75% through urea. Under seedling inoculation treatment, treatment with *Azotobactor* and *Azospirillum* recorded significantly highest grain weight per ear head as compared to control. Application of N through organic sources improving soil organic carbon and nitrogen balance in soil over N through inorganic sources.

***Key words*:** Integrated nitrogen management, Pearlmillet, Rainfed, Transplanting

Pearlmillet is an important rainfed crop and grown for both food and fodder. It is also used as a low cost substitute for maize in poultry and dairy feed. Of late, it has found certain place in beverage industry. In India, it is the fifth most important cereal grain crop next to rice, wheat, maize and sorghum.It is an imperative drought escaping cereal crop and grown in semi-arid and arid ecosystem of the world. India is the largest producer of pearlmillet in the world occupying about 9.4 million hectare with annual production of 10.1 million tonnes with average productivity of 1069 kg/ha (Economic Survey of India, 2011). Pearlmillet is the cereal whose area at national level has remained almost static during the past 60 years due to its adaptability to harsh habitat and lack of an alternative. In recent past, total production and productivity of pearlmillet has excelled that of sorghum.

Adoption of pearlmillet-wheat or pearlmillet-mustard sequence over a long period without a provision for adequate replenishment of nutrients results in declining of soil fertility. Withdrawal of nutrients from the soils of rainfed areas has remained much higher than their application (Gupta, 2001). In rainfed areas, farmers usually apply low quantity of FYM, other organic manure and chemical fertilizers. Among the various reasons, less fertilization is the main reasons for low productivity of Pealmillet. On an average, production of one tonne of dry fodder removes 9.4 kg N, 1.45 kg P,1.4 kg K,4.61 kg Ca,2.65 kg Mg and 1.85 kg S (Bose and Balakrishnan, 2001). The negative balance of nutrients under rainfed situation, calls for integrated nutrient management strategy involving integrated use of inorganic fertilizers, organic manure and bio-fertilizers. Application of nitrogenous fertilizer has played a key role in increasing food grains production in the country and will continue to do so in future (Prasad, 2011). Bio-fertilizers play an important role in increasing availability of nutrients as well as enhancing productivity in a sustainable manner. *Azotobactor* and *Azospirillum* are free living bacteria for N fixation in soils. On an average, the former can fix 20-40 kg N/ha, whereas, the later can fix 20 kg N/ha/year besides producing and releasing of growth promoting substances. The present investigation was, therefore, conducted to find out effect of integrated nitrogen management along with seedling inoculation with bio-fertilizers on performance of pearlmillet under rainfed conditions.

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MATERIALS AND METHODS

An experiment was conducted at Asalpur Research Farm of S.K.N. College of Agriculture, Jobner (Rajasthan) for two consecutive years during *kharif* season of 2006 and 2007 to find out the effect of integrated nitrogen management along with seedling inoculation with bio-fertilizers on performance of pearlmillet under rainfed. Experimental soil was loamy sand in texture, alkaline in reaction (pH 8.2), low in organic carbon (0.17 %), available nitrogen (128.68 kg/ha) and medium in available phosphorus 14.55 kg P_2O_5/ha potassium found (148.64 kg K_2O/ha). The experiment consisted of seven treatments of inorganic fertilizers and manure alone or in combinations (Control, 100% RDN through urea, 100% RDN through FYM, 75% RDN through FYM + 25% through urea, 50% RDN through FYM + 50% through urea, 25% RDN through FYM + 75% through urea and 80% RDN through vermicompost + 20% through urea) in main plots and three bio-fertilizer inoculation (Control, *Azotobactor* and *Azospirillum*) in sub replicated thrice in a split plot design.

Twenty four days old seedlings of pearlmillet cv. 'Raj 171' were transplanted at 40 x 10 cm spacing during both the years. A basal dose of phosphorus through single super phosphate was drilled in all required plots @ 30 kg kg/ha P_2O_5. The required quantity of FYM and vermicompost were applied 2 weeks before transplanting of the crop as per treatment. The half dose of nitrogen through urea as per treatment was applied as basal to crop before transplanting. The remaining half dose of nitrogen was top dressed at knee high stage when sufficient amount of rainfall occurs. Bio-fertilizers were applied as per treatment by dipping the roots of seedlings just before transplanting. Total rainfall received during crop season was 143.6 and 237.7 mm, during 2006 and 2007, respectively. Two life saving irrigations were applied in first year and one life saving irrigation in next year. Experimental data recorded for growth, yield attributes and yield were statistically analysed by Fisher's 'Analysis of Variance' technique (Fisher, 1950).

RESULTS AND DISCUSSION

Effect of nitrogen management

The present study indicated that all the treatments of integrated nitrogen management significantly increased the growth parameters *viz.* plant height, dry matter accumulation per plant, number of effective tillers per plant and total chlorophyll content in comparison to control at all the growth stages of crop (Table 1). Whereas, at harvest stage applications of 50% RDN through FYM + 50% through urea recorded significantly maximum plant height (172.5 cm) over control, 100% RDN through urea and 100% RDN through FYM but found statistically similar with rest of the treatments. The reasons for better growth under fertilizer and manure combination due to increased availability of nitrogen to plants initially through inorganic fertilizer and then by FYM. Manure supplying all the essential nutrients and improve physical condition of soil especially under light textured loamy sand soils. The increase in growth parameters through integrated nutrient management were also reported by Satyajeet and Nanwal (2007) and Parihar *et al*. (2010). Application of 50% RDN through FYM + 50% through urea remained by

Table 1. Effect of integrated nitrogen management on growth and yield attributes of pearlmillet (Pooled mean over two years)

Treatment	Plant height at harvest (cm)	Dry matter accumulation/ plant at harvest (g)	Effective tillers/plant	Chlorophyll content at 50% flowering (mg/g)	Grain weight/ear head (g)	Test weight (g)
Integrated nitrogen management						
Control	142.2	34.5	1.82	2.43	8.70	7.25
100% RDN through urea	156.0	39.9	2.65	2.76	9.40	7.31
100% RDN through FYM	159.7	39.5	2.46	2.67	9.76	7.86
75% RDN through FYM + 25% through urea	165.7	39.5	2.45	2.74	9.84	7.86
50% RDN through FYM + 50% through urea	172.5	43.4	2.99	2.80	10.84	7.89
25% RDN through FYM + 75% through urea	171.3	42.2	2.87	2.72	10.33	7.57
80% RDN through VC + 20% through urea	171.9	42.6	2.44	2.79	10.29	7.86
SEm±	2.7	0.7	0.04	0.05	0.25	0.18
CD (P=0.05)	7.9	1.9	0.13	0.14	0.76	NS
Inoculation						
Control	162.0	39.6	2.47	2.69	9.47	7.59
Azotobacter	163.2	40.9	2.58	2.72	10.23	7.72
Azospirillum	163.0	40.1	2.53	2.69	9.98	7.65
SEm±	0.73	0.46	0.05	0.02	0.14	0.11
CD (P=0.05)	NS	NS	NS	NS	NS	NS

and large at par with at 80% RDN through vermicompost + 20% RDN through FYM, 25% RDN through FYM + 75% through urea in terms of dry matter accumulation per plant during both the stages and found significantly better than remaining treatments of integrated nitrogen management. The maximum number of effective tillers per plant (2.99) was recorded with application of 50% RDN through FYM + 50% through urea followed by 25% RDN through FYM + 75% through urea, these two treatments proved significantly superior over all the treatments. The possible cause for improved growth under conjunctive use of nutrients might be due to increased availability of nitrogen to plants initially through inorganic fertilizer and then by FYM, matching to the need of crop throughout the cropping season. The results obtained in the present investigation are in line with the findings of Khan *et al.* (2000) and Choudhary and Gautam (2007).

Application of 50% RDN through FYM + 50% through urea fetched significantly highest weight of grains per ear head (10.84 g) as compared to rest of the treatments except 80% RDN through vermicompost + 20% through urea. The test weight of pearlmillet was influenced significantly with application of 50% RDN through FYM + 50% through urea over control and 100% RDN through urea but remained at par with remaining treatments. Data further showed that different combination of inorganic fertilizers and organic manures caused a remarkable effect on grain yield of pearlmillet over control wherein, application of 50% RDN through FYM + 50% through urea being at par with 80% RDN through vermicompost + 20% through urea significantly enhanced the grain yield over rest of the treatments and represented an increase of 56.6, 22.9, 22.2, 16.7 and 5.6 per cent respectively, over control, 100% RDN through urea, 100% RDN through FYM, 75% RDN through FYM + 25% through urea and 25% RDN through FYM + 75% through urea. The possible reason responsible for better production of yield components and yield could be the supply of nutrients in balanced amount and available form. The increased growth in terms of plant height, expansion of leaf lamina and chlorophyll content provided greater sites for photosynthesis and diversion of photosynthates towards sink (ear head and grain). Grain and biological yields of pearlmillet were also influenced significantly with different combination of fertilizers and manures wherein, application of 50% RDN through FYM + 50% through urea, 80% RDN through vermicompost + 20% through urea and 25% RDN through FYM + 75% RDN through urea were remained statistically similar with each other and proved significantly better over other remaining treatments of integrated nitrogen management. However, application of 50% RDN through FYM + 50% through urea recorded significantly highest harvest index (35.0%) over all the other treatments of integrated nitrogen management.

The higher grain yield of pearlmillet seemed to be the cumulative effect of yield attribute which was booted by balanced nutrients supply. The findings of present investigation are supported by those of Choudhary and Gautam (2007) and Parihar *et al*. (2010). Data presented in table 4 indicated that the combined application of inorganic fertilizers and manures or FYM alone significantly improved the organic carbon over 100% RDN through urea. In respect of available nitrogen, all the treatment of integrated nitrogen management remained statistically at par among

Table 2. Effect of integrated nitrogen management on growth and yield attributes and yields of pearlmillet (Pooled mean of two years)

Treatment	Yields (t/ha)		Harvest index (%)	Net returns ($\times 10^3$ ₹/ha)	B:C ratio ($\times 10^3$ ₹/ha)
	Grain	Stover			
Integrated nitrogen management					
Control	1.41	3.23	30.05	5.71	1.56
100% RDN through urea	1.80	3.77	30.76	8.70	1.80
100% RDN through FYM	1.81	3.59	33.40	6.86	1.56
75% RDN through FYM + 25% through urea	1.90	3.65	32.89	7.82	1.65
50% RDN through FYM + 50% through urea	2.22	4.12	34.72	11.17	1.95
25% RDN through FYM + 75% through urea	2.10	3.95	33.87	10.40	1.92
80% RDN through VC + 20% through urea	2.17	4.08	34.65	10.38	1.86
SEm±	0.03	0.06	0.09	0.35	0.03
CD (P=0.05)	0.10	0.19	0.29	1.04	0.09
Inoculation					
Control	1.83	3.71	32.86	8.40	1.73
Azotobacter	1.94	3.81	32.95	8.97	1.78
Azospirillum	1.92	3.9	32.91	8.80	1.76
SEm±	0.02	0.03	0.07	0.13	0.01
CD (P=0.05)	NS	NS	NS	NS	NS

themselves and superseded over control. The highest nitrogen balance was recorded with application of 100% RDN through FYM without inoculation (Table 3). It is clear from data presented in that the application of 50% RDN through FYM + 50% RDN through urea, 80% RDN through vermicompost + 20% through urea and 25% RDN through FYM + 75% through urea being at par with each other fetched significantly higher net returns and B:C ratio from pearlmillet over rest of the treatments.

Effect of seedling inoculation

In perusal of data of table 2 the seedling inoculation

Table 3. Effect of integrated nitrogen management on soil organic carbon and nitrogen content before transplanting and after harvesting

Treatment	Before transplanting		After harvesting	
	Organic carbon (%)	Nitrogen (kg/ha)	Organic carbon (%)	Nitrogen (kg/ha)
Integrated nitrogen management				
Control	0.210	130.08	0.181	90.54
100% RDN through urea	0.217	138.20	0.190	140.84
100% RDN through FYM	0.277	140.99	0.301	146.11
75% RDN through FYM + 25% through urea	0.256	139.82	0.258	139.30
50% RDN through FYM + 50% through urea	0.255	141.18	0.256	137.18
25% RDN through FYM + 75% through urea	0.235	141.22	0.233	137.37
80% RDN through VC + 20% through urea	0.262	142.42	0.270	141.44
SEm±	0.004	2.68	0.004	2.61
CD (P=0.05)	0.012	7.81	0.012	7.60
Inoculation				
Control	0.237	138.31	0.232	132.72
Azotobacter	0.250	139.71	0.248	134.84
Azospirillum	0.246	139.37	0.244	132.21
SEm±	0.009	1.52	0.003	1.42
CD (P=0.05)	NS	NS	NS	NS

Table 4. Effect of integrated nitrogen management on balance sheet (Pooled mean of two years)

Treatment	Initial nitrogen (kg/ha) (A)	Added nitrogen (kg/ha) (B)	Total (A + B) = C	Residual nitrogen in soil (kg/ha) (D)	Nitrogen uptake by crop (kg/ha) (E)
$N_0 I_0$	129.83	0.00	129.83	37.80	92.03
$N_0 I_a$	130.40	0.00	130.40	40.20	90.20
$N_0 I_b$	130.03	0.00	130.03	39.81	90.22
$N_1 I_0$	136.75	60.00	196.75	54.49	142.26
$N_1 I_a$	139.50	60.00	199.50	57.37	142.13
$N_1 I_b$	138.36	60.00	198.36	56.38	141.98
$N_2 I_0$	139.90	60.00	199.90	50.61	149.29
$N_2 I_a$	141.67	60.00	201.67	53.87	147.80
$N_2 I_b$	141.40	60.00	201.40	53.03	148.37
$N_3 I_0$	139.47	60.00	199.47	55.07	144.40
$N_3 I_a$	140.12	60.00	200.12	56.47	143.65
$N_3 I_b$	139.88	60.00	199.88	55.22	144.65
$N_4 I_0$	140.28	60.00	200.28	63.66	136.62
$N_4 I_a$	141.47	60.00	201.47	69.59	131.88
$N_4 I_b$	141.80	60.00	201.80	66.93	134.87
$N_5 I_0$	140.63	60.00	200.63	60.06	140.57
$N_5 I_a$	141.89	60.00	201.89	62.34	139.55
$N_5 I_b$	141.14	60.00	201.14	62.00	139.14
$N_6 I_0$	141.31	60.00	201.31	62.64	138.67
$N_6 I_a$	142.96	60.00	202.96	65.29	137.66
$N_6 I_b$	143.00	60.00	203.00	64.82	138.17

N_0=Control, $N_{1=}$100% RDN through urea, N_2=100% RDN through FYM, N_3=75% RDN through FYM + 25% through urea, N_4=50% RDN through FYM + 50% through urea, N_5=25% RDN through FYM + 75% through urea, N_6 =80% RDN through vermicompost + 20% through urea and I_0=Control, I_a=*Azotobacter, I_b=Azospirillum*

with bio-fertilizers (*Azotobactor* and *Azospirillum*) could not bring any significant improvement on growth parameters (plant height, dry matter production per plant, number of effective tillers per plant and total chlorophyll content), test weight, yields (grain, stover and biological) and harvest index of pearlmillet. Whereas, the seedling inoculation with bio-fertilizers were gave higher value of these parameters as compared to control. However, weight of grains per ear head was significantly enhanced due to seedling inoculation wherein Azotobactor recorded significantly highest weight of grains per ear head (10.24 g) over control but found at par with *Azospirillum*. The reason could be that *Azotobactor*/*Azospirillum* is known to produce antibiotic and antifungal substances which inhibit varieties of soil fungi. It can also synthesize and secrete thiamine, riboflavin, pyrodoxin, cynocobalamine, nicotinic acid, pentathonic acid, IAA and gibberellins or gibberellins like substances resulting in vigorous plant growth and dry matter which in turn resulted in better fertilization and ultimately the higher weight of grains. These findings corroborate the results of Meena and Gautam (2005). Data presented in table 2 further indicated that different treatments of seedling inoculation could not bring any significant improvement on net returns and B:C ratio of pearlmillet during both year of experimentation as well as in pooled analysis.

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