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EFFECT OF BIO-FERTILIZERS AND NITROGEN MANAGEMENT ON YIELD AND SOIL FERTILITY OF PEARL MILLET UNDER RAINFED CONDITION

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ABSTRACT
A field experiment was conducted at A1CRPDA Centre, S.D. Agricultural University, Sardarkrushinagar to find out the effect of integrated nutrient management practices in pearl millet crop under rainfed condition. The results showed that the effect of bio-fertilizers were not found significant in increasing the yield as well as soil available nutrients after harvest of the crop during all the years and on pooled basis. The treatment 50% N through urea + 50% N through FYM gave significantly higher seed yield of 1239, 822, 868, 972 and 975 kg ha^{-1} during years 2009, 2010, 2011, 2012 as well as in pooled, respectively. The similar trend was also observed in fodder yield. In terms of soil available nitrogen, phosphorus and potash, the treatment 50% N through urea + 50% N through FYM obtained significant improvement in soil fertility status of available N (174 kg/ha), phosphorus (48 kg/ha) and potash (204.8 kg/ha).

INTRODUCTION

Pearl millet [*Pennisetum glaucum* (L.) R. Br, emend. Stuntz.] is one of the important cereal crop cultivated under arid and semiarid tracts of North Gujarat region (Kanzaria *et al.*, 2010), cultivated in an estimated area of 68.43 lakh ha in India and 5.15 lakh ha in Gujarat (AICMIP 2013). India is the largest producer of pearl millet in terms of production (10.05 m t) with an average productivity of 1156 kg/ha (Bhardwaj *et al.*, 2014). It is generally cultivated in areas with annual rainfall between 150 and 700 mm (Knairwal and Yadav, 2005).

The beneficial effect of bio-fertilizers on plant is associated not only with the process of nitrogen fixation and improved nutrition of plants, but also with synthesis of complex biologically active compounds such as pyridoxine, biotin, gibberellin and other compounds which stimulates the germination of pearl millet seeds and accelerate plant growth under favourable environmental conditions (Golada, 2012). Nitrogen is an essential major nutrient for plant growth, which is closely associated with vegetative growth and development of plants; it plays an important role in plant metabolism by virtue of being an essential constituent of structural component of the cell wall and many metabolically active compounds. It is also a constituent of chlorophyll, which is important for harvest of solar energy (Bray, 1983). Use of organic sources along with chemical fertilizers not only conserves moisture and reduces erosion but also increases the nutrients use efficiency, thereby improving the overall productivity of soil (Sinha *et al.*, 2011).

Further, Long-term studies being carried out at several locations in India indicated that application of all the needy nutrients through chemical fertilizers have deleterious effect on soil health leading to unsustainable yields (Anand Swarup 2002). Therefore, there is a need to improve nutrient supply system in terms of integrated nutrient management involving the use of chemical fertilizers in conjunction with organic manures coupled with inputs of biological fertilizers. Integration of inorganic, organic and bio-fertilizers play a vital role in enhancing crop productivity and sustaining soil fertility, this proves great promise for increasing farmer's income. Nitrogen fixers and phosphate solubilizers contribute through biological fixation of nitrogen, solubilization of fixed nutrients and enhanced uptake of plant nutrients (Mane *et al.*, 2000). Keeping these views in mind, an experiment was conducted to find out the effect of bio-fertilizers, FYM as an organic source alone and along with inorganic fertilizers on yield of pearl millet and post harvest soil fertility status under rainfed condition.

MATERIALS AND METHODS

A field trial was conducted during *kharif*-2009 to *kharif*-2012 at the Instructional farm of AICRP for Dryland Agriculture, Centre for Watershed Management Participatory Research and Rural Engineering, S. D. Agricultural University, Sardarkrushinagar (Gujarat) having semi-arid and sub-tropical climate situated in 24º19' North latitude 72º19' East longitude and 154.52 meter above the mean sea level. The experimental

site is characterized by low and erratic rainfall occurring at different stages of crop growth. In the year 2009, 2010, 2011 and 2012 annual rainfall was 393.6, 1191.2, 915.3 and 628.2 mm, respectively. The soil was loamy sand in texture having high infiltration rate (15.2 cm/hour), poor maximum water holding capacity (20.65%) and also low in organic carbon (0.19%), available nitrogen (156.0 kg/ha), medium in available phosphorus (43.8 kg/ha) and potash (183.8 kg/ha) from 0-15 cm depth. The soil was neutral in reaction (pH 7.2 - 7.7).

The experiment was established in a factorial randomized block design with three replications, comprising of three levels of Bio-fertilizer; B_1: *Azotobactor,* B_2: PSB and B_3: *Azotobactor* + PSB, further five levels of N management; N_1: 100% RDN through chemical fertilizer, N_2: 75% RDN through chemical fertilizer + 25% RDN through FYM, N_3: 50% RDN through chemical fertilizer + 50% RDN through FYM, N_4: 50% RDN through FYM and N_5: 75% RDN through chemical fertilizer. Recommended doses of nitrogen, phosphorus and potash @ 80, 40 and 20 kg ha^{-1} were applied to pearl millet crop through urea, DAP and MOP, respectively.

The data on seed and fodder yields of pearl millet were recorded at harvest. The soil samples were drawn from each experimental unit after harvesting of pearl millet and analyzed for available nutrients as per the following methods; alkaline potassium permanganate method for nitrogen (Subbiah and Asija, 1956), Olsen's method for phosphorus (Olsen *et al.* 1954) and flame photometric method for potash (Jackson, 1973). The economics of different treatment combinations was worked out in terms of net return ha^{-1} and B:C (benefit cost ratio).

RESULTS AND DISCUSSION

Effect of Bio-fertilizers

The data (Table 1) revealed that the results were non-significant in influencing seed and fodder yields due to different bio fertilizers during all the years as well as in pooled. However, *Azotobactor* + PSB gave numerically higher seed (891 kg ha^{-1}) and fodder (3197 kg ha^{-1}) yields, except in the year 2011 in which the seed and fodder yield was increased significantly with application of *Azotobactor* + PSB. Among the different treatments of bio-fertilizers, the fertility status of soil also did not affected significantly in increasing the N, P and K content in soil after harvest of the crop (Table 2). The non-significant influence of different bio-fertilizers on yield and soil fertility might be due to its low water holding capacity, favorable soil reaction situation and presence of native bacteria in the soil. Moreover, the mechanism of action of microorganisms on plant growth and yield depends on producing growth promoting substances were also observed by Golada *et al.*, (2012), Girija Devi (2002), Patel *et al.*, (2002), Uddin *et al.*, (2009) and Rai, (2006).

Effect of Nitrogen Management

The data presented in Table 1 showed the significant increase in seed and fodder yield due to nutrient management treatments during all the years as well as in pooled result. The treatment N_3 *i.e.* 50% N through urea + 50% N through FYM gave significantly higher seed yield of 1239, 822, 868, 972 and 975 kg ha^{-1} during the years 2009, 2010, 2011, 2012 and in pooled results, which were 20.06, 8.73, 10.01, 7.40 and 11.94% higher as compared to 100% chemical fertilizer, respectively. During initial growth stages of crop, requirement of N is fulfilled by inorganic form of N applied through urea and in the later stages of crop growth, all the plant nutrients are released from FYM which have significantly influenced positively on yield and supplied plant nutrients throughout the period of crop growth. A positive effect of FYM on pearl millet yield had also been reported by Singh *et al.*, (1981) and

Table 1: Effect of integrated nutrient management treatments on seed and fodder yields of pearl millet under rainfed condition

Treatments	Yield (kg ha^{-1})									
	2009		2010		2011		2012		Pooled	
	Seed	Fodder	Seed	Fodder	Seed	Fodder	Seed	Fodder	Seed	Fodder
Bio-Fertilizers										
B_1: *Azotobactor*	1065	3527	736	2866	723	2876	886	2962	853	3058
B_2: PSB	1101	3500	740	2857	786	3203	890	2958	879	3130
B_3: *Azotobactor* + PSB	1071	3574	758	2911	828	3363	908	2938	891	3197
S.Em+	46.90	124.45	33.29	108.80	21.19	97.82	33.30	80.11	17.44	102.80
C.D. (0.05)	NS	NS	NS	NS	61.39	283.37	NS	NS	NS	NS
Nitrogen Management										
N_1: 100 % RDN through chemical fertilizer	1032	3547	756	2927	789	3196	905	2835	871	3126
N_2: 75 % RDN through chemical fertilizer + 25 % through FYM	1076	3551	799	3099	836	3379	948	3051	915	3270
N_3: 50 % RDN through chemical fertilizer + 50 % through FYM	1239	4072	822	3170	868	3522	972	3213	975	3494
N_4: 50 % through FYM 967	3136	626	2415	655	2620	775	2872	756	2761	
N_5: 75 % RDN through chemical fertilizer	1079	3362	723	2780	747	3019	872	2795	855	2989
S.Em+	60.51	160.72	43.01	140.46	27.36	126.28	42.99	103.42	22.51	132.72
C.D. (0.05)	175.42	462.28	124.54	393.06	79.25	365.83	124.53	299.61	63.03	380.20
C.V (%)	16.83	13.64	17.31	14.64	10.53	12.04	14.42	10.51	15.45	12.88
Rainfall (mm)	393.6 (17)	1191.2 (38)	915.3 (34)	628.2 (22)						
Interaction of B × N										
Y x B S.Em+									34.87	104.06
C.D. (0.05)									NS	NS
Y x N S.Em+									45.05	134.34
C.D. (0.05)									NS	NS
Y x B x N S.Em+									77.97	232.69
C.D. (0.05)									NS	NS

Note: The values of rainy days are given in parenthesis

Table 2: Effect of integrated nutrient management treatments on soil fertility status after harvest of the Pearl millet crop

Treatments	Soil Available N					Soil Available P_2O_5					Soil Available K_2O				
	2009	2010	2011	2012	Pooled	2009	2010	2011	2012	Pooled	2009	2010	2011	2012	Pooled
Bio-fertilizers															
B_1: *Azotobactor*	152.0	157.6	163.4	159.0	158.0	47.5	48.9	35.3	38.9	41.6	192.8	197.3	176.4	184.0	187.6
B_2: PSB	154.2	159.5	165.8	162.0	160.4	48.0	50.8	36.8	39.4	44.0	193.7	199.2	177.0	185.0	188.7
B_3: *Azotobactor* + PSB	155.2	160.4	166.4	163.0	161.2	49.0	52.1	38.5	39.6	45.6	196.0	201.1	179.6	188.0	191.2
SEM ±	2.0	2.4	2.1	2.1	2.2	0.9	1.2	1.1	0.8	1.0	3.9	4.8	4.0	4.0	4.2
CD @ 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Nitrogen Management															
N_1: 100 % RDF through chemical fertilizer	151.3	157.4	162.2	157.0	157.0	47.4	49.4	35.8	38.3	42.7	189.8	194.4	172.8	181.0	184.5
N_2: 75 % RDF through Chemical fertilizer + 25 % through FYM	156.0	161.2	166.8	161.0	161.2	48.8	51.4	36.9	39.4	44.1	198.7	203.9	182.0	190.0	193.7
N_3: 50 % RDF through Chemical fertilizer + 50 % through FYM	168.7	173.9	175.4	178.0	174.0	52.8	55.2	40.8	43.3	48.0	210.0	215.6	192.8	201.0	204.8
N_4: 50 % through FYM	150.7	155.8	164.4	159.0	157.5	47.2	49.8	36.4	38.9	43.1	190.3	195.1	173.3	181.0	185.0
N_5: 75 % RDF through Chemical fertilizer	142.3	147.5	157.1	152.0	149.7	44.6	47.1	34.4	36.9	40.7	181.8	187.0	167.4	176.0	178.1
SEM ±	2.6	3.2	2.7	2.7	1.4	1.2	1.5	1.4	1.1	0.7	5.0	6.2	5.2	5.2	2.8
CD @ 5%	7.5	9.1	7.8	7.8	4.0	3.5	4.4	4.2	3.1	1.9	14.5	17.9	15.1	15.1	7.8
CV %	5.0	6.0	4.9	5.0	5.2	7.6	9.1	11.7	8.1	9.1	7.7	9.3	8.8	8.4	8.5
Interaction of B × N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Initial Soil Fertility	148.0	151.0	157.0	168.0	156.0	45.5	49.2	36.2	44.2	43.8	181.0	183.0	168.0	203.0	183.8

Agarwal and Kumar (1995). Increase in seed and stover yield might be due to addition of FYM resulted in stimulation of the enzyme activity which promotes the recycling of nutrients in the soil ecosystem (Singaram and Kamalakumari, 1995).

Looking to the fertility status of soil, the different nutrient management treatments showed significant results in terms of available nitrogen, phosphorus and potash (Table 2). Treatment N_3 *i.e.* 50% N through urea + 50% N through FYM obtained significant improvement in soil fertility in terms of available N (174 kg/ha), phosphorus (48 kg/ha) and potash (204.8 kg/ha) which were comparatively higher than rest of the treatments. Similar beneficial effect of organic source on soil fertility was also recorded by Acharya *et al.* (1988) and Prasad, (2014). Consequently, FYM has been reported to improve the soil fertility and productivity (Badiyala and Verma, 1990). Application of FYM also increases cation exchange capacity and microbial activity in soil besides supplying macro and micro plant nutrients. It helps in minimizing leaching losses, improving buffering capacity and influencing the redox conditions in the soil (Gaur *et al.*, 1971). Kumar *et al.*, (2007) also showed positive significant effect of FYM @ 2 t/ha and 3 t/ha on seed and stover yield. These results are also in conformity with the results of earlier workers by Patel *et al.*, (2007).

Interaction Effect

The interaction effect between bio-fertilizers and nutrient management were found non-significant in producing seed and fodder yields as well as enhancing the soil available N, P_2O_5 and K_2O after harvest of the crop in all the years and in pooled results (Table 1 and 2). This might be due to the non significant effect of biofertilizers which leads to show its equal response when interacted with nitrogen management treatments. Similar effect of integration of inorganic and organic sources on crop production was also reported by Guggari and Kalaghatagi (2001), Choudhary and Gautam (2007) and Kanzaria *et al.* (2010).

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