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Integrated Nitrogen Management in Maize-Wheat Cropping Sequence on Typic Haplustalfs of Western India

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Abstract: A field investigation involving three sources (chemical, organic and chemical + organic) and three levels of nitrogen (50, 75 and 100% of the recommended dose), in conjunction with two levels of bio-inoculant (no-inoculation and inoculation with *Azotobacter*) was carried out on a Typic Haplustalfs of Udaipur (Rajasthan), India, using maize and wheat crops in cropping sequence. Application of N at 100% of the recommended dose through organic manure alone or in integration with inorganic fertilizer on equal N basis as compared to when applied solely through chemical fertilizer enhanced the growth, yield attributes and yields of both the crops along with uptake of nutrient and protein content. Inoculation with *Azotobacter* also improved these parameters under study. Improvements in available nutrient status of the soil under these treatments suggest the rational way to sustain the crop production.

Key words: Integrated nitrogen management, cropping system.

Maize (*Zea mays* L.) – wheat (*Triticum aestivum*) is a well established cropping sequence of sub-humid southern plains of Rajasthan, India. Inspite of cultivating high yielding cultivars of maize and wheat the production per unit area is very low. There is a wide gap between actual and potential yield, which could be attributed to inefficient and insufficient management of production factors, particularly nitrogen. In general, Indian soils are deficient in nitrogen. Removal of nitrogen by crop plants in large amounts, coupled with low recovery of applied nitrogen, which seldom exceeds 50%, calls for its efficient management. Increased use of fertilizer nitrogen, an important feature of modern dynamic chemical-dependent agriculture, may lead to pollution problem (Williams, 1992; Virmani, 1994), in addition to being non- remunerative, unless the fertility of soil is maintained at sustainable level through integrated use of diverse nitrogen sources.

Materials and Methods

A field study was conducted on Typic Haplustalfs at Maharana Pratap University of Agriculture & Technology, Udaipur. The soil of the experimental field was clay loam in texture, having EC of 0.88 dS m^{-1} and pH of 8.2, medium in available N (327 kg N. ha^{-1}) and high in available P (22.3 kg ha^{-1}) and had adequate drainage. The treatments comprised of three nitrogen sources, chemical fertilizer (urea), organic manure (bio-gas slurry, containing 1.7, 1.1 and 1.6% N, P_2O_5 and K_2O, respectively) and chemical fertilizer + organic manure on equal N-basis; three levels of N 50, 75 and 100% of the recommended dose

Table 1. Effect of sources and levels of nitrogen in conjunction with Azotobacter inoculation on available nutrient status of the soil under maize-wheat cropping sequence

Treatment	Available nutrient status in soil (kg ha^{-1})		
	Nitrogen	Phosphorus	Potassium
N source			
Chemical fertilizer (Urea)	257	37.8	185
Organic manure (BGS)	281	40.2	191
Chemical fertilizer + organic manure (1:1)	269	39.0	188
SEm±	3.6	0.5	1.7
CD at 5%	10.4	1.7	5.0
N level (% of recommended dose)			
50	257	37.8	185
75	269	39.0	188
100	280	40.2	191
SEm±	3.6	0.5	1.7
CD at 5%	10.4	1.7	5.0
Seed inoculation			
No inoculation	263	38.4	186
Azotobacter inoculation	274	39.6	189
SEm±	2.9	0.4	1.4
CD at 5%	8.5	NS	NS

BGS = Bio-gas slurry.

(90 and 100 kg N ha^{-1} for maize and wheat, respectively) and two levels of inoculation, no-inoculation and inoculation with *Azotobacter*. The experiment was laid out in factorial randomized block design with three replications and taking maize cultivar Navjot in kharif (monsoon, 1995) and wheat cultivar Lok-1 in rabi (winter, 1995-96) as test crops in maize-wheat cropping sequence.

A basal dose of 60 and 40 kg P_2O_5 ha^{-1} to maize and wheat crop, respectively, was given as placement at the time of sowing. Nitrogen through biogas slurry was applied to the respective plot one day prior to sowing with thorough mixing, whereas N through chemical fertilizer was applied in three splits. Half the N was given at sowing and the remaining half was applied at knee high stage (30 DAS) and teaseling (45 DAS) in maize and tillering (60 DAS) and grand growth (85 DAS) in wheat. Seeds were inoculated with *Azotobacter* as per the treatment. Crops were sown at an inter-row spacing of 60 cm in maize and 22.5 cm in wheat with a respective seed rate of 25 and 100 kg ha^{-1}. Maize crop

Table 2. Effect of sources and levels of nitrogen in conjunction with Azotobacter inoculation on yield attributes and yield of crops in maize + wheat cropping sequence

Treatment	Yield attributes							
	Wheat				Maize			
	Dry matter (g plant^{-1})	1000-grain weight	Grain (t ha^{-1})	Straw (t ha^{-1})	Dry matter (g plant^{-1})	1000-grain weight	Grain (t ha^{-1})	Straw (t ha^{-1})
N source								
Chemical fertilizer (Urea)	165.5	41.6	4.5	6.3	179.9	193.7	2.6	6.5
Organic (BGS) manure	185.2	47.4	5.3	7.0	206.9	214.2	3.4	7.6
Chemical fertilizer + organic manure (equal N basis)	175.6	44.6	4.9	6.6	193.5	203.8	2.8	7.0
SEm±	1.3	0.9	0.06	0.07	3.4	3.5	0.07	0.2
CD at 5%	4.0	2.5	0.2	0.2	9.7	10.2	0.2	0.5
N level (% of recommended dose)								
50	165.1	41.6	4.5	6.3	169.7	189.4	2.5	6.5
75	175.5	44.6	4.9	6.6	194.7	205.7	3.0	7.0
100	185.7	47.4	5.3	7.0	215.8	216.0	3.3	7.5
SEm±	1.3	0.9	0.06	0.07	3.4	3.5	0.07	0.2
CD at 5%	4.0	2.5	0.2	0.2	9.7	10.2	0.2	0.5
Seed inoculation								
No inoculation	170.2	43.1	4.8	6.6	187.8	202.4	2.7	6.8
Azotobacter inoculation	180.7	45.9	5.0	6.7	199.0	205.0	3.1	7.3
SEm±	1.1	0.7	0.05	0.06	2.8	2.9	0.06	0.1
CD at 5%	3.2	2.1	0.16	NS	7.9	NS	0.2	0.4

BGS = Bio-gass slurry, R.D. = Recommended dose.

was thinned to a spacing of 20 cm within the row.

Maize crop was irrigated only under prolonged dry spell, while wheat crop was irrigated five times. Growth parameters, yield attributes and yields of maize and wheat were recorded to evaluate the treatment effects. Grain and stover/straw samples collected at harvest were analyzed in diacid extract for phosphorus using Dickman and Bray (1940) method of color development, potassium using flame-photometer and Zn, Fe, Mn and Cu using Atomic Absorption Spectrophotometer. Nitrogen in plant materials was analyzed using colorimetric method (Lindner, 1944). Soil samples to a depth of 0.15 cm were also drawn after the harvest of wheat crop in the maize-wheat

Table 3. Effect of sources and levels of nitrogern in conjunction with Azotobacter inoculation on uptake of nutrient by crops in maize-wheat cropping sequence

Treatment	Major nutrients ($kg\ ha^{-1}$)			Micro-nutrients ($g\ ha^{-1}$)				% protein in grain
	N	P	K	Zn	Fe	Cu	Mn	
Maize								
Source of N								
Chemical fertilizer (Urea)	101	19	103	285	1386	118	316	12.8
Organic manure (BGS)	155	31	143	409	1787	175	415	14.9
Chemical fertilizer + organic manure (equal N basis)	124	25	123	321	1552	140	349	13.8
SEm±	2.8	0.5	3.9	12.2	35.7	3.5	12.7	0.2
CD at 5%	8.2	1.6	11.2	35.1	102.5	9.9	36.6	0.7
N-level (% of recommended dose)								
50	99	20	99	272	1337	114	301	12.7
75	127	24	124	335	1574	142	357	13.9
100	154	31	146	408	1815	178	423	14.9
SEm±	2.8	0.5	3.9	12.2	35.7	3.5	12.7	0.2
CD at 5%	8.2	1.6	11.2	35.1	102.5	9.9	36.6	0.7
Seed inoculation								
No inoculation	115	33	118	320	1512	136	342	13.4
Azotobacter inoculation	139	27	128	357	1638	152	379	14.3
SEm±	2.3	0.4	3.2	9.9	2.9	2.8	11.3	0.2
CD at 5%	6.7	1.3	NS	28.7	83.7	8.1	29.9	0.6
Wheat								
Source of N								
Chemical fertilizer (Urea)	117	21	145	236	2604	257	601	11.7
Organic manure (BGS)	160	32	172	292	2983	312	718	13.8
Chemical fertilizer + organic manure (equal N basis)	137	26	157	263	2784	284	662	12.8
SEm±	3.7	0.6	3.7	5.4	39	6	11	0.2
CD at 5%	10.7	1.7	10.8	15.6	113	17	32	0.7

Table 3 contd....

Table 3. Contd....

Treatment	Major nutrients (kg ha^{-1})			Micro nutrients (g ha^{-1})				% protein in grain
	N	P	K	Zn	Fe	Cu	Mn	
N-level (% of recommended dose)								
50	117	21	144	236	2599	257	606	11.7
75	137	26	158	264	2787	284	652	12.8
100	160	32	172	292	2986	311	723	14.0
SEm±	3.7	0.6	3.7	5.4	39	6	11	0.2
CD at 5%	10.7	1.7	10.8	15.6	113	17	32	0.7
Seed inoculation								
No inoculation	130	24	154	256	2756	277	641	12.2
Azotobacter inoculation	146	28	162	272	2825	292	679	13.4
SEm±	3.0	0.4	3.0	4.4	32	5	9	0.2
CD at 5%	8.7	1.4	8.8	12.7	92	14	26	0.6

cropping sequence from individual plot to assess the available nitrogen (Subbiah and Asija, 1956), phosphorus (Olsen *et al*., 1954) and potash (Ammonium acetate extraction, Richards, 1968) status of the soil.

Results and Discussion

The results indicated that application of nitrogen solely through organic manure or integrated use of organic and chemical fertilizer on equal nitrogen basis (50:50) upto 100% of the recommended dose, in general, improved the soil-available nutrient status (Table 1), dry matter production, 1000-grain weight and yields of both the crops (Table 2) in maize-wheat cropping sequence over the values observed under treatment receiving N solely through chemical fertilizer. Likewise, the total uptake of major (N, P, K) and micro (Zn, Fe, Mn, Cu) nutrients by the grain and stover/straw and grain protein content (Table 3) was also significantly higher in the produce harvested from the plots receiving N, either solely through organic manure or when supplied through integrated use of organic manure and chemical fertilizer.

An improvement in available nutrient status of the soil with the incorporation of bio-gas slurry alone or in integration with chemical fertilizer could be attributed to the slow decomposition of organic manure producing acids and enhancing soil biological activity, which in turn provided congenial physical conditions (Biswas *et al*., 1971), conserved the soil nitrogen and increased the availability of other nutrients as being its constituents (Acharya, 1958), as well as mineralized from the native source in soil (Kwakye, 1988). This ultimately improved the yield attributes and grain yield of maize and wheat crops in cropping sequence. It is further evident from the data that seed inoculation with *Azotobacter* significantly improved the N-status of the soil and growth, yield attributes, yield and uptake of nutrients by both the crops under study, which could be attributed to the creation of congenial environment for better root growth through secretion of growth-promoting substances and availability of nitrogen being fixed from the atmosphere (Shah and Joshi, 1986; Hooda and Dahiya, 1992).

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