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Research Paper

Yield, quality and nutrient status of soil under different integrated nitrogen management practices in wheat (*Triticum aestivum*) – forage cowpea (*Vigna unguiculata*) cropping sequence

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ABSTRACT

A field experiment was conducted during winter and summer season of 2011–12 and 2012–13 at college Agronomy farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, to study the yield, quality and nutrient status of soil under different integrated nitrogen management practices in wheat (*Triticum aestivum L.*) — forage cowpea [*Vigna unguiculata (L.*) Walp.] cropping sequence. The experiment was laid out in randomized block design with 21 treatment combinations, comprising 7 nitrogen management through chemical fertilizer and organic manures and 3 bio-fertilizer inoculants. Application of 75% RDN from chemical fertilizer + 25% RDN from FYM followed by 100% RDN from chemical fertilizer and 75% RDN from chemical fertilizer + 25% from vermicompost resulted significantly higher grain yield with protein content in wheat. Significantly higher nutrient contents were recorded in the plots fertilized with 25% RDN from chemical fertilizer + 25% RDN from FYM + 25% RDN from vermicompost + 25% RDN from castor cake followed by 50% RDN from chemical fertilizer + 25% vermicompost + 25% castor cake. Seed inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum* resulted in the higher grain yields and protein content in wheat. This treatment also showed higher available nitrogen, potassium and phosphorus status of soil. Significantly higher green and dry fodder yield, and protein content in forage cowpea were recorded owing to residual effect of combined seed inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum*. Application of 25% RDN chemical fertilizer + 25% from FYM + 25% from vermicompost + 25% from castor cake along with combined seed inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum* improved nutrient status of soil in wheat—forage cowpea sequence.

Key words: Bio-fertilizer, Cowpea, INM, Nutrient status, Quality, Wheat, Yield

Wheat is an important cereal crop in the world and provides about 20% of total food calories for the human race (Hossain *et al.,* 2006).

Gujarat ranks sixth in production and area under wheat crop in the country. Area and production under wheat crop in Gujarat was 12.50 thousand hectares and 29.07 thousand tonnes respectively (Government of Gujarat, 2011). An adequate and optimum supply of nitrogen is required for vegetative growth and for maintaining genetical potential, while the deficit and excess reduce the production potential of crop. The supplementary and complementary use of organic manures, viz. FYM, vermicompost, castor cake and inorganic fertilizers plays an important role in the growth and development of crop (Virmani, 1994). Non-symbiotic bacteria like *Azotobacter* and *Azospirilium* are potential bio-fertilizers, capable of contributing nitrogen to a number of non-legume crops by trapping aerial reservoir (Ram and Mir, 2006).

The integrated approach of nutrient supply by using organic, inorganic and bio-fertilizers is gaining importance, because this system not only reduces the use of costly inorganic fertilizers but also it is an eco-friendly approach (Sawarkar *et al.,* 2013). The application of organic manures may serve as an excellent source of macro and micro nutrients (Kathuria *et al*., 2005).

The package of practices so far generated on fodder cowpea is for getting the maximum green and dry fodder production during lean period of the summer season.

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MATERIALS AND METHODS

A field experiment was carried out at the College Agronomy Farm, B.A. College of Agriculture, Anand Agricultural University, Anand, Gujarat during *rabi* and summer seasons of 2011–12 and 2012–13 with succeeding forage cowpea taken after main crop of wheat on the same plot.

Composite soil samples were collected from the experimental site up to the depth of 0–15 cm and 15–30 cm before commencement of the experiment, and were analyzed for various physico-chemical properties. The soil of experimental site was sandy loam with *p*H 7.5, 0.38% organic carbon, 6/dS EC_2, 199.5 kg/ha available N, 32.17 kg/ha P_2O_5 and high K_2O of 389.0 kg/ha.

The wheat variety 'GW-366' released by Wheat Research Station, Junagadh Agricultural University, Junagadh, Gujarat, during 2006, was used in the present investigation.

The variety 'EC - 4216' is the most promising variety of fodder cowpea. It is mid duration variety, produces about 30 to 35 t/ha green fodder. It is recommended for the Northern, Western and Central India.

Twentyone treatment combinations comprising 7 N management through chemical fertilizer and manures (F), viz. F_1, 100 % RDN (from chemical fertilizer); F_2, 75% RDN + 25% RDN from FYM; F_3, 75% RDN + 25% RDN from vermicompost; F_4, 75% RDN + 25% RDN from castor cake; F_5, 50% RDN + 25% RDN from FYM + 25% RDN from vermicompost; F_6, 50% RDN + 25% RDN from FYM + 25% RDN from castor cake; and F_7, 25% RDN + 25% RDN from FYM + 25% RDN from vermicompost + 25% RDN from castor cake, and 3 levels of bio-fertilizer inoculation (B), viz. B_1, no bio-fertilizer inoculation; B_2, *Azotobacter chroococcum* inoculation; B_3, *Azotobacter chroococcum* + *Azospirillum lipoferum* inoculation. Recommended dose of P_2O_5 @ 60 kg/ha in the form of single superphosphate was applied basal at the time of sowing of wheat crop. No fertilizer was given to succeeding forage cowpea. The experiment was laid out in factorial randomized block design with 3 replications.

The harvested crop of each net plot was sundried, threshed and the grains were cleaned manually and weighed plot-wise in kilogram. The plot-wise straw yield was obtained by deducting the grain yield from the total produce (dry biomass) and recorded in kg/plot and by multiplying it with conversion factor grain and straw yield were converted into tonnes/ha.

The chemical analysis of the oven-dry samples straw as well as grain was carried out by Jakson digestion method. Nitrogen content of wheat grains was determined by Kjeldahl's method as suggested by Jackson (1973). Protein content of the grain was computed by multiplying the value of nitrogen content with conversion factor 6.25.

The initial soil samples drawn from 0–15 cm and 15–30

Table 1. Effect of integrated nitrogen management and bio-fertilizer levels on yields, quality parameters and nutrient status of soil after harvesting of wheat (pooled data of 2 years)

Treatment	Yield(t/ha)		Quality parameter(%)			Nutrient status of soil(kg/ha)			
	Grain	Straw	Nitrogen content in the grains	Nitrogen content in the straw	Protein content	Organic carbon (%)	Available N	Available K_2O	Available P_2O_5
Nitrogen management (F)									
F_1	3.57	7.77	1.79	0.96	11.21	0.47	257.3	52.60	179.2
F_2	3.71	7.61	1.77	0.93	11.08	0.54	274.8	54.79	191.5
F_3	3.56	7.13	1.77	0.92	11.05	0.51	273.1	55.59	228.6
F_4	3.37	6.74	1.76	0.91	10.98	0.47	269.3	56.69	231.8
F_5	2.72	6.53	1.73	0.91	10.80	0.59	276.6	57.61	235.1
F_6	2.58	6.56	1.71	0.88	10.66	0.55	278.9	60.11	241.5
F_7	2.62	5.51	1.67	0.85	10.44	0.59	283.0	63.33	255.4
SEm±	0.71	0.226	0.02	0.01	0.12	0.01	1.96	0.50	18.72
CD (*P*=0.05)	0.20	0.783	0.05	0.04	0.33	0.02	5.52	1.40	NS
Bio-fertilizer inoculation (B)									
B_1	3.03	6.55	1.72	0.90	10.73	0.53	268.7	56.46	218.4
B_2	3.14	6.95	1.74	0.91	10.90	0.53	272.9	56.37	224.1
B_3	3.32	7.01	1.77	0.92	11.04	0.53	278.2	58.90	227.4
SEm±	0.047	0.086	0.01	0.01	0.08	0.00	1.28	0.75	0.91
CD (*P*=0.05)	0.131	0.243	0.03	NS	0.22	NS	3.61	NS	2.57
F × B	NS	NS	NS	Sig.	Sig.	Sig.	Sig.	Sig.	NS
CV (%)	9.52	8.19	4.61	6.10	4.61	4.85	3.04	3.67	2.65

Details of treatments are given under Materials and Methods.

cm depth before experiment. Samples were ground and then sieved through 2 mm sieve. The initial composite soil sample was analyzed for different physico-chemical properties.

The soil samples, drawn after harvesting of each crop from each plot during both the years, were dried, ground and then sieved through 2 mm sieve. The soil samples were collected after harvesting of the wheat crop from each treated plots for determination of soil status by standard methods of analysis.

RESULTS AND DISCUSSION

Effect of nitrogen management

Yield of wheat: Maximum higher grain yield (3.71 t/ha) was obtained under the treatment F_2 (Table 1). Biswas and Reddy (2010), Kulkarni *et al.* (2015) and Singh *et al.* (2015) found that application of 75% N through chemical and 25% from FYM, as organics might have exerted favourable effect on the soil chemical, physical and biological properties resulting of better utilization of nutrients which in turn resulted in greater values of growth and yield parameters. Treatment F_1 recorded significantly higher straw yield (7.77 t/ha) which was probably owing to higher level of nitrogen which gave more vegetative growth, resulting better utilization of nutrients, water, solar radiation and increased metabolic activity, which might have resulted in maximum dry matter production (Arun Kumar *et al.,* 2009; Kulkarni *et al.,* 2015; Baishya *et al*., 2015).

Quality parameters: Higher nitrogen content in the grain, straw and protein content in wheat grains were recorded higher under the treatment F_1. Rana and Singh (2006), Yadav *et al.* (2015) and Singh *et al.* (2015) observed that plants usually assimilate nitrogen ions in definite deficient population, increasing the availability of nutrient, usually results in better uptake of nutrients by plants, which have increased the nitrogen metabolism leading to high nutrient content in the wheat grains and straw.

Nutrient status of soil: The treatments F_5 and F_7 recorded the highest value of organic carbon, while treatment F_7 showed significantly higher available soil nitrogen (283.05 N kg/ha) and highest available phosphorus (63.33 kg/ha) in the soil. Tolanur and Badanur (2003), Dixit *et al*. (2015) and Singh *et al*. (2015) observed that higher values of nutrient content in the soil after harvesting of wheat crop might be owing to the fact that organic manure is slow process and it will take longer time to release the nutrients in the soil that's why such type of result was registered during both the years and pooled result.

Effect of bio-fertilizer

Yield of wheat: Highest grain yield (3.22 t/ha) and higher

Table 2. Interaction effect of integrated nutrient management and bio-fertilizer levels on quality parameters and nutrient status of soil after harvesting of wheat crop (pooled data of 2 years)

Nitrogen management (F)	Bio-fertilizer inoculation (B)											
	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3	B_1	B_2	B_3
	Nitrogen content in straw (%)			Protein content in grain (%)			Organic carbon (%)			Available N (kg/ha)			Available P_2O_5 (kg/ha)		
F_1	0.92	0.97	0.98	11.14	11.26	11.24	0.48	0.46	0.46	256.9	259.6	255.4	50.98	51.46	55.36
F_2	0.98	0.89	0.94	10.67	11.28	11.30	0.51	0.54	0.56	275.1	274.6	274.7	53.02	55.41	55.95
F_3	0.93	0.92	0.93	10.91	10.94	11.31	0.53	0.51	0.48	266.7	275.9	276.7	53.70	56.12	56.96
F_4	0.92	0.92	0.90	11.10	11.06	10.77	0.47	0.46	0.49	256.7	263.9	287.2	57.01	53.70	59.36
F_5	0.92	0.95	0.85	10.17	10.71	11.53	0.59	0.59	0.59	271.5	275.5	282.9	57.29	56.43	59.10
F_6	0.82	0.87	0.96	10.78	10.49	10.72	0.55	0.54	0.57	274.8	279.5	2825	60.25	59.36	60.71
F_7	0.85	0.83	0.86	10.34	10.58	10.41	0.59	0.60	0.59	279.6	281.6	287.9	62.99	62.15	64.84
SEm±		0.02			0.20			0.01			3.40			0.86	
CD (P=0.05)		0.06			0.58			0.03			9.56			2.42	

Details of treatments are given under Materials and Methods.

straw yield (7.013 t/ha) were noticed under seed inoculation with treatment B_3. The improvement in grain yield with treatment B_3 over B_1 was to the tune of 09.79%. Treatment B_3 also registered significantly higher nitrogen content in wheat grain (1.77%) under pooled result, but was at par with treatment B_2.

Quality parameters: The highest protein and nitrogen content of wheat was registered under similar treatment. Effect of bio-fertilizer inoculation on organic carbon content in the soil after harvesting of wheat crop was found non-significant.

Nutrient status of soil: The seed inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum* (B_3) registered significantly highest available soil nitrogen and available potassium in the soil (280.4 and 277.40 kg/ha respectively). Effect of bio-fertilizer inoculation on available phosphorus content in the soil was found non-significant.

Interaction effect

Combinations of organic, inorganic fertilizer with bio-fertilizer that (F_1B_3 and F_2B_1) recorded significantly higher nitrogen content in the straw than rest of the treatment combinations (Table 2). While treatment combination F_5B_3 recorded significantly higher protein content in the grains of wheat (11.53%). Vora *et al.* (2010) observed that the maximum nitrogen and protein content from interaction of nitrogen management and bio-fertilizer inoculation may be owing to enhanced absorption of available N in protein synthesis. The highest sugar was attributed to cumulative effect of adequate supply of nutrients and higher available N content which in turn helped the formation and transfer of protein from roots to grains.

Soil status of the investigated soil recorded the maximum organic carbon content under F_7B_2 combination than other treatment, except the treatment combinations F_5B_1, F_5B_2, F_5B_3, F_7B_2, F_7B_3 and F_6B_3. This increase in organic carbon was owing to combined application of organic, inorganic and bio-fertilizer inoculation as source, which enhanced the decomposition of organic matter by increased microbial activities. The significantly higher available nitrogen content (287.91 kg/ha) and available phosphorus in the soil (64.84 kg/ha) were recorded under treatment combination F_7B_3 than rest of the treatment combinations.

Table 3. Residual effect of integrated nutrient management and bio-fertilizer levels on yield and protein content of succeeding forage cowpea (pooled data of 2 years)

Treatment	Green fodder yield (q/ha)	Dry fodder yield (q/ha)	Crude protein content (%)
Nitrogen management (F)			
F_1	204	49	13.06
F_2	249	60	13.19
F_3	235	57	13.40
F_4	211	51	13.60
F_5	259	62	13.76
F_6	249	60	13.69
F_7	275	66	14.05
SEm±	12.81	3.09	0.12
CD (*P*=0.05)	NS	NS	0.33
Bio-fertilizer inoculation (B)			
B_1	233	56	13.38
B_2	238	57	13.52
B_3	250	60	13.71
SEm±	4.35	1.05	0.08
CD (*P*=0.05)	12.24	2.95	0.21
F × B	NS	NS	NS

Residual effect on succeeding forage cowpea

There was no significant residual effect of green-fodder yield and dry-fodder yield of forage succeeding cowpea. Application of 25% RDN chemical fertilizer + 25% RDN from FYM + 25% RDN from vermicompost to wheat crop recorded significantly higher crude protein content (Table 3). Significantly higher yields were obtained under seed inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum* treatment.

This might be due to fact that all the fixed-N in the wheat crop is not much utilized by wheat crop. Significantly higher of crude protein content was recorded under seed inoculation *with Azotobacter chroococcum* + *Azospirillum lipoferum* treatment (Nag and Roy, 2008).

Based on these findings, it could be concluded that application of 75% recommended dose of nitrogen (RDN) from chemical fertilizer + 25% from FYM resulted in higher grain yield with better protein content.

Dual inoculation with *Azotobacter chroococcum* and *Azospirillum lipoferum* recorded higher yield and improved soil nutrient status after harvesting of the wheat crop. Nitrogen management (25% RDN from chemical + 25% from FYM + 25% from vermicompost 25% from castor cake) to wheat crop and seed inoculation with *Azotobacter chroococcum* + *Azospirillum lipoferum* increased crude protein content, and green fodder and dry-matter yield.

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