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IMPACT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, QUALITY AND NUTRIENT UPTAKE BY WHEAT (*TRITICUM AESTIVUM* L.) IN A MEDIUM BLACK CALCAREOUS SOILS

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ABSTRACT
A field experiment was conducted at Junagadh, Gujarat during the *rabi* season of 2014-15 to evaluate the impact of integrated nutrient management on yield, quality and nutrient uptake by wheat in a medium black calcareous soils. The results of the experiment indicated that highest grain (4123 kg ha^{-1}) and straw yield (6408 kg ha^{-1}) of wheat were recorded under application of 75 % NP + Full K of RDF + S + $ZnSO_4$ + FYM + *Azotobacter* + PSB (T_7). The quality parameter, protein content (13.96%) was recorded maximum in treatment T_8 *i.e.* 75 % NPK of RDF + S + $ZnSO_4$ + FYM + *Azotobacter* + PSB + KSB while the other quality parameters like protein yield (550 kg ha^{-1}) and test weight (47.57 g) were observed maximum under treatment T_7. The total uptake of N, P, K, Ca, Mg, S, Fe, Zn, Mn and Cu (113.8 kg ha^{-1}, 21.80 kg ha^{-1}, 101.8 kg ha^{-1}, 42.85 kg ha^{-1}, 49.35 kg ha^{-1}, 29.88 kg ha^{-1}, 2865 g ha^{-1}, 1075 g ha^{-1}, 1448 g ha^{-1}, 1099 g ha^{-1}) by wheat were observed higher in the treatment T_7. Thus, integrated nutrient management improved the yield, quality and nutrient uptake by wheat.

INTRODUCTION

The farmers are using high analyzed inorganic fertilizers to get higher yield of wheat. But continuous and uncontrolled use of these chemical fertilizers ultimately deteriorate the soil health or physical, chemical and biological properties. Soils which receive plant nutrients only through chemical fertilizers are showing declining productivity despite being supplied with sufficient nutrients. The physical condition of the soil is deteriorated as a result of long-term use of chemical fertilizers, especially the nitrogenous ones. Therefore, integrated nutrient management is highly essential to maintain the soil fertility, productivity and minimize the land degradation and environmental pollution for sustainable agriculture. Primarily INM refers to combining old and modern methods of nutrient management into ecologically sound and economically optimal farming system that uses the benefits from all possible sources of organic, inorganic and biological components/ substances in a judicious, efficient and integrated manner (Janssen, 1993). Boosting yield, reducing production cost and improving soil health are three inter-linked components of the sustainability triangle (Singh *et al.,* 2008). Verma *et al.* (2005) was also revealed that the integration of inorganic fertilizers with organic manures will not only sustain the crop production but also will be effective in improving soil health and enhancing the nutrient use efficiency. On account of continuing world energy crisis and spiraling price of chemical fertilizer, the use of organic manure as a renewable source of plant nutrients is assuming importance. In this endeavor proper blend of organic manure and inorganic fertilizer is important not only for increasing yield but also for sustaining soil health (Kumar *et al.,* 2013). Considerable work has been done on INM in wheat, but not much attention has been paid towards inclusion of biofertilizers as a component in it. In association with the aforementioned facts, the present investigation was planned to study the effect of integrated nutrient management on yield, quality and nutrient uptake by wheat.

MATERIALS AND METHODS

The experiment was conducted at D-7 plot of Instructional Farm, Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh during *rabi* season 2014-15. The experimental plot was clayey in texture and alkaline in reaction with $pH_{2.5}$ 8.10, $EC_{2.5}$ 0.65 dSm^{-1}. The soil was low in available nitrogen (242 kg ha^{-1}), zinc (0.41 mg kg^{-1}) and medium in available phosphorus (48.1kg ha^{-1}), available potassium (230 kg ha^{-1}), available sulphur (11.60 mg kg^{-1}), iron (9.94 mg kg^{-1}), and high in manganese (16.40 mg kg^{-1}) and copper (3.64 mg kg^{-1}). Randomized Block Design with eight treatments replicated thrice was employed in this study. The treatment details were T_1- Absolute control, T_2 - RDF *i.e.* 120-60-60 kg N-P_2O_5-K_2O ha^{-1}, T_3 - RDF + 40 kg S ha^{-1}, T_4 - RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1}, T_5 - RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1}, T_6 - 75 % N + Full PK of RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 tons t ha^{-1} + *Azotobacter* @ 10 ml kg^{-1} seed, T_7 - 75 % NP + Full K of RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @ 10 ml kg^{-1} seed + PSB @ 10 ml

kg^{-1} seed, T_8 - 75 % NPK of RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @ 10 ml kg^{-1} seed + PSB @ 10 ml kg^{-1} seed + KSB @ 10 ml kg^{-1} seed. Nitrogen, phosphorus, potassium and sulphur were applied as per the treatments in the form of Urea, DAP, MOP and COSAWET. In addition to this, $ZnSO_4$ and FYM were also applied before sowing the crop in previously opened furrows. The half dose of nitrogen and full dose of phosphorus, potassium and sulphur were applied before sowing the crop in open furrow. Remaining half of nitrogen was applied in two equal splits as topdressing at 30 DAS and 60 DAS. The seeds were treated with *Azotobacter* (*A. chroococcum*), PSB (*Bacillus coagulans*) and KSB (*Frateuria aurantia*) @ 10 ml kg^{-1} seed as per the treatments, shade dried and then sowing was taken at 5-6 cm depth keeping inter row spacing of 22.5 cm and then covered with the soil.

Wheat variety GW-496 was used for sowing with seed rate of 120 kg ha^{-1} on 20th November during 2014 and harvested on 23rd February 2015. At harvest, yield and yield attributes of wheat were recorded. The soil samples were collected at random before the experiment to analyze the initial soil properties. These samples were analyzed for pH (1:2.5 soil:water suspension), electrical conductivity by conductivity meter (Jackson, 1973), available N was estimated by alkaline permanganate method (Subbiah and Asija , 1956), available P by Olsen's method (Olsen *et al*., 1954), available K by ammonium acetate extraction method (Jackson, 1973) and available S was estimated by turbidimetric method (Williams and Steinbergs ,1959). Available Iron, Zinc, Manganese and Copper were extracted with DTPA and determined by atomic absorption spectrophotometer (Lindsay and Norvell, 1978). The chemical analysis of plant sample was carried out by wet digesting with Di-acid and Triacid mixture as per the procedure outlined by (Jackson, 1973) and to determine concentrations of N, P, K, Ca, Mg, S, Fe, Zn, Mn and Cu at harvest using procedure described by (Jackson, 1973). Protein content in grain was determined by multiplying nitrogen content in grain (%) by a factor 6.25 (Gassi *et al*., 1973). The data were subjected to statistical analysis by adopting appropriate analysis of variance (Cochran and Cox, 1967). Wherever the F values were found significant at 5 per cent level of probability, the critical difference (C.D.) values were computed for making comparison among the treatment means described by Panse and Sukhatme (1985).

RESULTS AND DISCUSSION

Yield and yield attributes

The data on grain and straw yield of wheat are presented in table 1 revealed that significantly highest grain (4123 kg ha^{-1}) and straw yield (6408 kg ha^{-1}) of wheat were recorded under treatment T_7 *i.e.* 75 % NP + Full K of RDF (120-60-60 kg N-P_2O_5-K_2O ha^{-1}) + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @ 10 ml kg^{-1} seed + PSB @ 10 ml kg^{-1} seed. However, grain yield was found statistically at par with different integrated treatments T_4, T_5, T_6 and T_8 whereas straw

Table 1: Effect of different INM treatments on yield, yield attributes and quality parameters of wheat

Treatments	Yield	Yield attributes		Quality parameters						
	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Plant height (cm)	No. of total tillers $metre^{-1}$ row length	No. of effective tillers $metre^{-1}$ row length	Length of spike (cm)	No. of spikelets $spike^{-1}$	Protein content (%)	Protein yield (kg ha^{-1})	Test weight (1000 grains) (g)
T_1	2240	3208	64.71	66.37	48.27	6.09	12.40	9.98	223	40.64
T_2	2995	3346	79.20	73.70	53.60	6.37	12.67	10.09	302	41.14
T_3	3009	3624	79.37	81.63	55.33	6.56	13.03	10.97	330	42.85
T_4	3356	4591	82.86	85.17	59.67	6.73	13.80	11.86	399	43.70
T_5	3565	5040	82.90	86.32	63.03	6.87	14.37	12.41	441	44.37
T_6	3858	5814	86.02	87.24	67.20	7.05	14.73	12.90	500	45.21
T_7	4123	6408	88.75	90.40	74.00	7.32	16.40	13.30	550	47.57
T_8	3861	5915	86.55	89.00	70.60	7.19	15.07	13.96	527	46.36
C.D.(P = 0.05)	860	852	8.34	13.69	10.22	0.69	1.83	1.44	109	4.23

Table 2: Effect of different INM treatments on uptake of major nutrients by grain and straw of wheat

Treatments	Uptake of major nutrients by grain and straw of wheat(kg ha^{-1})											
	N		P		K		Ca		Mg		S	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	35.70	10.82	3.82	2.89	6.96	27.27	5.06	8.58	5.68	9.30	3.05	6.13
T_2	48.30	11.27	5.94	3.14	9.25	30.56	7.07	9.41	8.02	10.62	4.05	6.71
T_3	52.79	12.61	6.23	3.45	9.51	35.20	7.71	11.16	9.11	13.26	4.40	8.48
T_4	63.86	16.65	7.60	5.03	10.88	47.25	9.03	17.09	10.61	19.41	5.31	11.28
T_5	70.50	18.86	9.08	6.06	12.07	57.76	8.71	20.49	11.74	24.24	5.73	13.70
T_6	80.08	22.46	10.77	7.43	13.25	70.60	10.69	26.42	13.44	30.42	6.82	16.95
T_7	88.06	25.73	12.95	8.85	14.36	87.48	11.59	31.27	13.44	35.91	8.76	21.12
T_8	84.40	23.31	11.22	8.05	13.84	78.04	11.90	27.60	12.84	35.43	8.12	17.92
S.Em. +												
C.D.(P = 0.05)	17.45	4.50	2.69	1.22	3.22	14.18	3.14	4.66	3.19	4.48	1.83	3.30
C. V. %												

Table 3: Effect of different INM treatments on uptake of micronutrients by grain and straw of wheat

Treatments	Uptake of micronutrients (g ha^{-1})							
	Fe		Zn		Mn		Cu	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	388	784	124	214	148	308	102	311
T_2	534	859	192	251	219	379	144	340
T_3	548	961	216	289	239	464	155	408
T_4	648	1272	284	404	287	625	193	490
T_5	724	1467	328	449	327	739	196	597
T_6	803	1746	377	535	390	870	225	721
T_7	927	1938	454	621	450	998	259	840
T_8	838	1832	409	605	454	952	228	825
S.Em. +								
C.D.(P=0.05)	230	251	103	98	108	132	66	141
C. V. %								

yield remained statistically at par with treatments T_6 and T_8. The lowest grain (2240 kg ha^{-1}) and straw (3208 kg ha^{-1}) yield were observed under treatment T_1 (absolute control). The increase in grain yield with the inoculation of various biofertilizers (*Azotobacter*, PSB, KSB) might be due to increase in nutrient availability through solubilization of insoluble inorganic fertilizers, decomposition of organic compounds, production of plant growth promoting substances which favours the growth and development of crop and it possess anti-pathogenic activity aided in soils and ultimately resulted higher grain yield. These results are in agreement with the findings of Bhat (2013), Sharma *et al*. (2013), Meena *et al*. (2013) and Patel *et al*. (2015).

The data pertaining to yield attributes are given in table 1 indicated that, among the various treatments evaluated the treatment receiving 75 % NP + Full K of RDF (120-60-60 kg N-P_2O_5-K_2O ha^{-1}) + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter*@ 10 ml kg^{-1} seed + PSB@ 10 ml kg^{-1} seed recorded significantly highest plant height (88.75 cm), highest spike length of 7.32 cm which were statistically at par with treatments T_4, T_5, T_6 and T_8. Treatment T_7 which constitutes 75 % N + Full PK of RDF(120-60-60 kg N-P_2O_5-K_2O ha^{-1}) + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter*@10 ml kg^{-1} + PSB @ 10 ml kg^{-1} seed seed produced significantly more number of total tillers per row metre (90.40) which was statistically at par with treatments T_3, T_4, T_5, T_6 and T_8. **S**ignificantly more number of effective tillers per row metre (74.00) and maximum number of spikelets per spike (16.40) at harvest were noticed under treatment T_7 *i.e.* 75 % NP + Full K of RDF (120-60-60 kg N-P_2O_5-K_2O ha^{-1}) + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @10 ml kg^{-1} seed + PSB @10 ml kg^{-1} seed and it was found on par with treatments T_6 and T_8. The positive impact of availability of individual plant nutrients and humic substances from farmyard manure and balanced supplement of major and micronutrients through inorganic fertilizers (RDF, sulphur, zinc) might have induced cell division, expansion of cell wall, meristematic activity, photosynthetic efficiency and regulation of translocation of sugar resulting in the enhancement of yield related parameters. Improvement in yield due to combined application of inorganic fertilizer and organic manure might be attributed to control release of nutrient in the soil through mineralization of organic manure which might have facilitated better crop growth (Katkar *et al*., 2011). Similar findings were also reported by, Azam *et al*. (2010), Sharma *et al*. (2013) and Shah and Kumar (2014).

Quality

From the data on table 1, it can be inferred that quality parameter, protein content (13.96 %) was recorded significantly maximum in treatment T_8 *i.e.* 75 % NPK of RDF (120-60-60 kg N-P_2O_5-K_2O ha^{-1}) + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @ 10 ml kg^{-1} seed + PSB @ 10 ml kg^{-1} seed + KSB @ 10 ml kg^{-1} seed which was remained statistically at par with treatments T_6 and T_7. While the other quality parameters like protein yield and test weight (1000 grains) were observed significantly maximum under treatment T_7 *i.e.* 75 % NP + Full K of RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @ 10 ml kg^{-1} seed + PSB @ 10 ml kg^{-1} seed with value of 550 kg ha^{-1} and 47.57 g, respectively. It was found statistically at par with treatments T_6 and T_8 in terms of protein yield and at par with treatments T_4, T_5, T_6 and T_8 in terms of test weight. Significantly lowest protein content, protein yield and test weight (1000 grains) of wheat were registered in treatment T_1 (Absolute control). The integrated use of RDF, sulphur, zinc, FYM and biofertilizers enhanced the amino acid synthesis which are the building blocks of protein molecules and consequently increased the protein yield of wheat. These results are in concordance with most similar previous studies of Virkar and Tumbare (2010), Ram *et al*. (2014), Seema *et al*. (2014) and Bipin *et al*. (2015).

Nutrient uptake

The data presented in table 2 and 3 revealed that significantly highest uptake of N, P, K, Ca, Mg, S, Fe, Zn, Mn and Cu by grain and straw of wheat were observed under treatment T_7 *i.e.* 75 % NP + Full K of RDF (120-60-60 kg N-P_2O_5-K_2O ha^{-1}) + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter* @10 ml kg^{-1} seed + PSB@ 10 ml kg^{-1} seed except Ca and Mn uptake by grain which were found to be higher under treatment T_8 *i.e.* 75 % NPK of RDF + 40 kg S ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} + FYM @ 5 t ha^{-1} + *Azotobacter*@ 10 ml kg^{-1} seed + PSB @10 ml kg^{-1} seed + KSB@ 10 ml kg^{-1} seed. Mg uptake by grain was found to be higher in both the treatments T_6 and T_7. The total uptake which is the sum of both grain and straw uptake of various nutrients were recorded in the following order of N (113.8 kg ha^{-1}), P (21.80 kg ha^{-1}), K (101.8 kg ha^{-1}), Ca (42.85 kg ha^{-1}), Mg (49.35 kg ha^{-1}), S (29.88 kg ha^{-1}), Fe

(2865 g ha^{-1}), Zn (1075 g ha^{-1}), Mn (1448 g ha^{-1}) and Cu (1099 g ha^{-1}). The increase in uptake of nutrients might be due to solubilizing action of organic acids produced during decomposition of farmyard manure and the chelation activity of biofertilizers might have increased the release of native soil nutrients, stimulated microbial growth in soil, and favoured root growth which had finally led to increased uptake of nutrients by wheat. The results corroborate with the similar findings of Mitra *et al*. (2010), Devi *et al*. (2011), Bahadur *et al*. (2013) and Kumar *et al*. (2015).

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