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Effect of INM on Content of NPKS Zn in Grain and Stover of Maize-Wheat Cropping System

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A B S T R A C T

A field experiment was conducted at Student's Instructional Farm of Chandra Shekhar Azad University of Agriculture and Technology, Kanpur to study the effect of Vermicompost, FYM, Sulphur, Zinc, Azotobacter and PSB on growth, yield and uptake of nutrients in maize and their residual effect on succeeding wheat was studied during 2018-19 and 2019-20. A significant improvement was recorded with respect to content of nutrients in grain as well as stover/straw of maize and succeeding wheat with the application of S and Zn @ 20 and 5 kg ha^{-1} along with RDF of NPK as compared to control during both the years. The maximum content of nutrients (NPKSZn) were estimated with the application of T_{14} (100% RDN+25 % N- VC +S+Zn+Az+PSB) but remained statistically at par with the treatments of T_{13} where FYM was given instead of Vermicompost in maize and wheat during both the years of experimentation.

Introduction

Maize (*Zea mays*), is known as "queen of cereals", the world's third most important cereal crop in term of production stands after wheat and rice. The maize contributes 9 per cent of total food grain production of the country. The area under maize cultivation is 8.6 mha with a production 21.7 mt. in India whereas, in U.P. the production is 1.5 ton/ha with an area 1.1 mha (Anonymous, 2013). It is cultivated with different crop-sequence under various agro-climatic regions of the country. Hence, it is considered as potential driver of crop diversification under different situations (Jat *et al.,* 2011).

Wheat is the most important cereal crop of the world. It is the staple food of different countries of the world. With the existing rice-wheat system there is emerging challenges of natural resource degradation, declining crop productivity and ecological problems. Among different maize-base cropping systems, maize-wheat cropping system ranks first (Jat *et al.,* 2011).

The application of well decomposed farm Yard Manure(FYM) to soil has been practiced for many centuries for increasing crop yield, soil organic matter, microbial activities and improving soil fertility and soil structure for sustainable agriculture for long time (Blair *et al.,* 2005; Kundu *et al.,* 2006) however, proper combination of both organic and inorganic fertilizers have better effects on crop growth and development and yield component of crop than alone (Budaruddin *et al.,* 1999: Hossain *et al.,* 2002: Manna *et al.,* 2005). Balance application of N, P, K fertilizers with FYM was best option for higher crop yield in maize wheat cropping system (Brar, *et al.,* 2015).

The inoculation of biofertilizer in combination with limited doses of rock phosphate or SSP produced higher and sustainable crop yield, maintained the soil health and reduced the P fertilizer cost (Singhal *et al.,* 2012). The excess and imbalance use of nutrients allow continuous nutrient mining from the soil resulting to poor the crop productivity and soil health. Integrated nutrient management system may be suitable for sustainable yield, quality traits and better environment. The existing nutrient management practices are based mainly on individual crop.

There is need to develop integrated nutrient management module in a cropping system. There is meager information about integrated nutrient management on maize-wheat cropping system. Therefore, with keeping in mind the present scenario the experiment was carried out to evaluate the effect of integration of organic and inorganic sources along bio-inoculants on growth, yield and uptake of nutrients in maize and their residual effect on wheat.

Materials and Methods

A field experiment was conducted during *kharif* and *rabi* seasons of 2018-19 and 2019-20 at Student's Instructional Farm, C.S. Azad University of Agriculture and Technology, Kanpur (UP) situated at between 25 ^{0}26' to 26 ^{0}58' North latitude and 79 ^{0}31' to 80 ^{0}34' East longitude at an elevation of 125.9 m above mean sea level.

The region falls under agro-climatic zone V (Central Plain Zone) of Uttar Pradesh. The soil of the experimental field was alluvial in origin. The experiment was laid out in completely randomized block design with three replications treatments replicated thrice and plot size was 6×5 cm^2. Maize Variety Azad Uttam was sown in *kharif* whereas HD-2967 was taken as wheat variety during *rabi* season. was g In the present experiment fourteen treatments *viz*., T_1 (control), T_2 (75 % RDN), T_3 (75 % RDN +25 % N-FYM), T_4 (75 % RDN+25 % N-VC), T_5 (75 % RDN +25 % N-FYM +S+Zn+Az+PSB), T_6 (75 % RDN +25 % N-VC +S+Zn+Az+PSB), T_7 (100% RDN), T_8 (100% RDN+S), T_9 (100% RDN+ S+Zn), T_{10} (100% RDN+S+Zn+Az+PSB), T_{11} (100% RDN+25 % N-FYM), T_{12} (100% RDN+25 % N-VC), T_{13} (100% RDN+25 % N-FYM+ S+Zn+Az+PSB), T_{14} (100% RDN+25 % N-FYM+S+Zn+Az+PSB) were applied in maize.

Whereas in wheat a similar RDF (@ 120:60:40) of NPK was given in all the treatments of maize. The soil of the experimental field was sandy loam in texture which was low in organic carbon (3.35 g kg^{-1}), slightly alkaline in reaction. Furthermore, the soil was low in available N (156 kg ha^{-1}), medium in available P (10.34 kg ha^{-1}), high in available K (198.16 kg ha^{-1}), low in available S (14.20 kg ha^{-1} and medium in available Zn (0.36 mg kg_{-1}). Treatment wise plant samples were collected from each plot at harvest of the crop for analysis of N, P, K, S and Zn content and their uptake in grain and Stover/straw of Maize and wheat.

The five plants having intact leaves were selected randomly from each plot. The stover/straw samples were first air-dried and kept in oven at 60-70 ^{0}C for drying till the 12 hours to become free from moisture. Afterwards the samples were ground in a willey mill and stored in clean polythene bags. Similarly, dried grain samples were also ground oven dried, passed through 2 mesh sieve and stored in the sample bottles.

Determination of N, P, K, S and Zn content in plant samples

Nitrogen

N is determined by Kjeldahl method given by Jackson (1967).

Phosphorus

P is determined colorimetrically by vanadate-molybdate yellow colour method as advocated by Chapman and Pratt (1961).

Potassium

K determination has been done using flame photometric method (Chapman and Pratt, 1961) outlined by Jackson (1967).

Sulphur

S is determined through turbidimetric method (Chesnin and Yien, 1956).

Zinc

Zn is extracted from plant with the help of atomic absorption spectrophotometer (Lindasey and Norwell, 1978).

Results and Discussion

Effect of treatments on content of nutrients

Nitrogen content in grain and stover of maize

The concentration of N in grain and stover showed significant variation due to treatments during both the years as well as on pooled mean basis as presented in table 1.0. The addition of either FYM or VC besides 75% or 100% RDN increased the N content in seed and stover. However, the addition of S+Zn, Azotobacter +PSB with 75 % RDN+FYM or VC significantly contributed for N content in grain and stover. The highest N content were recorded under T_{14} (100% RDN +25 % N-VC+S+Zn+Az+PSB) which had at par effect with T_{13} (100% RDN+25% N-FYM+S +Zn+Az+PSB), T_{10} (100% RDN+S+Zn+Az+ PSB) and T_6 (75% RDN+25% N-VC+S+Zn+ Az+PSB) but significantly superior to rest of the treatments. This may be due to organic sources considerably participates in mineralization of nutrients and easily absorbed by the plants and result to higher accumulation of nutrients. Similar results were also reported by Steinbach *et al.*, (2004). These results are in agreement with the findings of (Rasool *et al.*, 2016; Balyan and Kumpawat 2008). This might be due to the fact that combined application of organic and inorganic sources of nutrients modified the soil environment, besides providing the physical properties of soil and also the slow microbial decomposition of humus gradually increases the N availability during cropping period, which was manifested in higher N content maize.

Phosphorus content

It is evident from finding that increasing doses of N from 75 to 100% had increased the P content in grain and stover of maize. It was noticed that P content in grain as well as stover were higher in treatments consisting organic manure along with 75% and 100% RDN. The highest P content was recorded with the application of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) however, statistically at par with the treatments of T_{13} (100% RDN+25% N-FYM+S+Zn+Az+PSB), T_{10} (100% RDN+S+Zn+Az+PSB) and T_6 (75% RDN+25% N-VC+S+Zn+Az+PSB) during both the years. The availability of phosphorus in soil may be increased due to use of organics as decomposition of organic manure progressed; various organic acids produced which solubilize phosphatase and other phosphate bearing minerals and thereby lower the phosphate fixation and higher absorption of P by plants Vidyavathi *et al.,* (2012). Wilkinson *et al.,* (1999) reported that N can increase P content in plants by increasing root growth, by increasing the ability of roots to absorb and translocates P, and by decreasing soil pH as a result of absorption of N. These results are in accordance with the findings of (Rayees *et al.,* 2017 and Karki *et al.,* 2005).

Potassium content in maize

The application of 100% RDN+25% N-VC+S+Zn+Az+PSB) recorded significantly higher K content than other treatments of 75 or 100 % RDN integrated either with FYM or VC with or without S, Zn, Azotobacter and PSB but was statistically at par with the treatments T_{13} (100% RDN+25% N-FYM+ S+Zn+Az+PSB), T_{10} (75% RDN+S+Zn+Az+ PSB), T_6 (75% RDN+25% N-VC+S+Zn+Az+ PSB) and T_5 (75% RDN+25% N-FYM+S+ Zn+Az+PSB) however numerically superior. The results are in close conformity with the findings of (Brar *et al.,* 2001 and Wagh 2002). It may be ascribed that the application of organic manure may have the solubilizing action of certain organic acids produced during their decomposition and hold K in available form thereby increasing its absorption and uptake (Vidyavathi *et al.,* 2012).

Sulfur content

The application of S alone or in combination of Zn or Zn+Az+PSB (T_{10}) along with 100% RDN increased the content of S in grain and stover. Further combination of S with either VC or FYM increased the concentration of S in grain and stover. The application of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) registered highest S concentration, however remained statistically at par with T_{13} (100% RDN+25% N-FYM+S+Zn+Az+PSB), T_{10} (100% RDN+S+Zn+Az+PSB) and T_6 (75% RDN+25% N-VC+S+Zn+Az+PSB) but numerically higher to T_1 (control).

The highest accumulation of S might be due to fortification of sulphur along with 100% NPK Joshi *et al.,* (2013). Conjoint application of S with organic manure significantly increased the S uptake in grain and stover might be due to the synergistic action of Nitrogen and Sulfur dose. As organic manure enriches soil fertility through addition of organic matter in the soil along with sulfur application which enhances easy and faster mineralization of organic matter, which helps in increasing the availability and uptake of nutrient (Patel *et al.,* (2003).

Zn content

The application of Zn significantly contributed for its concentration in grain and stover over no application. The highest Zn content was recorded under the treatment of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) which was statistically at par with T_{13} (100% RDN+25% N-FYM+S+Zn+Az+PSB), T_{10} (100% RDN+S+Zn+Az+PSB) and T_6 (75% RDN+25% N-VC+S+Zn+Az+PSB) and significantly superior to rest of the treatments. The application of Zn increased its concentration in maize and it is further increased when applied in combination of FYM or VC+ S+Zn+Az+PSB). Increased content of zinc in grain and stover with integrated use of organic and inorganic fertilizers may be attributed due to the adequate supply of this nutrient thereby improved Zn content in grain and stover coupled with total biomass (Meena *et al*., 2006). Furthermore, it might be due to Zn involved in formation of chelates with organic ligands which lowered susceptibility to adsorption, fixation and precipitation in the soil ultimately improved absorption by plants during entire growth period (Kuniyal *et al*., 2012).

Effect on content of nutrients in grain and straw of wheat

Nitrogen content

The data regarding N content in grain and straw presented in table 4.0. The content of N increased with the increasing dose of RDN from 75 to 100%. It was further increased with addition of VC or FYM in combinations of 75 or 100% RDN. The maximum N content was recorded with T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) but found on par with T_{13} (100% RDN+25% N-FYM+S+Zn+Az+PSB), T_6 (75% RDN+25% N-VC+S+Zn+Az+PSB) and T_5 (75% RDN+25% N-FYM+S+Zn+Az+PSB). It is evident from table that the addition of FYM or VC with or without S+ Zn + Azotobacter +PSB further increased the concentration of N in wheat. It may be ascribed that organic manure released nutrients following decomposition and mineralization that would have increased the availability of plant nutrient Yadav *et al.*, (2018). The combined application of chemical fertilizers along with organic sources stimulates the concentration of nutrients and because of stimulated microbes flush and improved root growth due to congenial soil physical, chemical and biological condition. Apart from N fixing biofertilizers enhances the soil N and PSB produces the organic acids which may partly be responsible for quick release of nutrients resulted into more content of nutrients in grain as well as straw (Kumar and Dhar, 2010; Meena *et al.*, 2014).

Phosphorus content and uptake

The data of P content presented in table 4.0 The highest P content was recorded with T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) however, remained statistically at par with the treatments of T_{13} (100% RDN+25% N-FYM+ S+Zn+Az+PSB), T_{10} (100% RDN+S+Zn+Az +PSB), T_6 (75% RDN+25% N-VC+S+Zn+ Az+PSB) and T_5 (100% RDN+25% N-FYM+ S+Zn+Az+PSB) during both the years and on pooled mean basis. The P content increased significantly when S, Zn and Azotobacter and PSB applied individually or in combination with 100% RDN in maize, however, it remained statistically at par with each other. With regard to 75 % RDN combinations, T_6 (75% RDN+25% N-VC+S+Zn+Az+PSB) showed better response in case of P but showed at par with T_5 during both the years. The N and P have mutually synergistic effects resulting into growth stimulation and enhanced uptake of both the elements (Sumner *et al.,* 1986). Additionally, decomposition of organic manures, various phenolic and aliphatic acids are produced which solubilize phosphatase and other phosphate bearing minerals and thereby lowers the phosphate fixation and increase its availability (Dotaniya *et al.*, 2014). Incorporation of FYM and PSB along with inorganic P increase the availability of P to crop and mineralization of organic P due to microbial action and enhanced mobility of P (Sharma *et al.*, 2013; Dwivedi *et al.,* 2007 and Bahadur *et al.,* 2012).

Table.1 Effect of different treatments on N and P content in grain stover of maize

Treatments combinations	N content (%) Grain		N content (%) Stover		P content (%) Grain		P content (%) Stover	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1. Control	1.31	1.30	0.50	0.48	0.28	0.27	0.09	0.09
T_2. 75%RDN	1.36	1.38	0.53	0.56	0.31	0.33	0.13	0.12
T_3. 75% RDN+25% N-FYM	1.39	1.42	0.55	0.58	0.33	0.36	0.16	0.15
T_4. 75%RDN+25%N-VC	1.41	1.44	0.56	0.59	0.34	0.37	0.17	0.16
T_5. 75%RDN+25%N-FYM+S+Zn+Az.+PSB	1.51	1.54	0.65	0.68	0.41	0.45	0.26	0.24
T_6. 75%RDN+25%N-VC+S+Zn+Az.+PSB	1.53	1.56	0.67	0.70	0.42	0.46	0.28	0.26
T_7. 100%RDN	1.42	1.45	0.57	0.60	0.35	0.38	0.18	0.17
T_8. 100%RDN+S	1.47	1.50	0.61	0.64	0.37	0.40	0.19	0.18
T_9. 100%RDN+S+Zn	1.49	1.52	0.63	0.66	0.39	0.42	0.22	0.21
T_{10}. 100%RDN+S+Zn+Az.+PSB	1.55	1.58	0.68	0.71	0.43	0.46	0.29	0.27
T_{11}. 100%RDN+25%N –FYM	1.46	1.49	0.60	0.63	0.38	0.41	0.21	0.20
T_{12}. 100%RDN+25%-VC	1.48	1.51	0.62	0.65	0.39	0.42	0.22	0.21
T_{13}. 100%RDN+25% N-FYM+S+Zn+Az.+PSB	1.56	1.59	0.69	0.72	0.44	0.48	0.31	0.29
T_{14}. 100%RDN+25% N-VC+S+Zn+Az.+PSB	1.58	1.61	0.71	0.74	0.46	0.50	0.32	0.30
SE(m)	0.026	0.032	0.015	0.023	0.015	0.019	0.019	0.012
CD (5%)	0.067	0.090	0.044	0.067	0.045	0.054	0.054	0.034

Table.2 Effect of treatment on K and S content in grain and stover of maize

Treatments combinations	K content (%) Grain		K content (%) Stover		S content (%) Grain		S content (%) Stover	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1. Control	0.36	0.34	1.08	1.07	0.06	0.05	0.06	0.07
T_2. 75%RDN	0.39	0.42	1.1	1.13	0.07	0.09	0.12	0.11
T_3. 75% RDN+25% N-FYM	0.41	0.44	1.12	1.15	0.09	0.12	0.15	0.13
T_4. 75%RDN+25%N-VC	0.43	0.46	1.13	1.16	0.10	0.13	0.16	0.14
T_5. 75%RDN+25%N-FYM+S+Zn+Az.+PSB	0.51	0.54	1.22	1.25	0.20	0.24	0.24	0.22
T_6. 75%RDN+25%N-VC+S+Zn+Az.+PSB	0.53	0.56	1.24	1.27	0.22	0.26	0.25	0.23
T_7. 100%RDN	0.44	0.47	1.14	1.17	0.11	0.13	0.16	0.15
T_8. 100%RDN+S	0.46	0.49	1.16	1.19	0.15	0.18	0.19	0.17
T_9. 100%RDN+S+Zn	0.49	0.52	1.20	1.23	0.18	0.21	0.21	0.19
T_{10}. 100%RDN+S+Zn+Az.+PSB	0.54	0.57	1.25	1.28	0.23	0.27	0.26	0.24
T_{11}. 100%RDN+25%N –FYM	0.47	0.5	1.18	1.21	0.15	0.18	0.2	0.18
T_{12}. 100%RDN+25%-VC	0.48	0.51	1.19	1.22	0.16	0.19	0.21	0.19
T_{13}. 100%RDN+25% N-FYM+S+Zn+Az.+PSB	0.55	0.58	1.26	1.29	0.24	0.28	0.29	0.27
T_{14}. 100%RDN+25% N-VC+S+Zn+Az.+PSB	0.56	0.60	1.28	1.31	0.25	0.29	0.30	0.28
SE(m)	0.023	0.028	0.031	0.037	0.012	0.015	0.019	0.012
CD (5%)	0.067	0.081	0.099	0.122	0.036	0.045	0.054	0.034

Table.3 Effect of treatments in Zn content of grain and stover of maize

Treatments combinations	Zn content Grain (mg kg^{-1})		Zn content Stover (mg kg^{-1})	
	2018-19	2019-20	2018-19	2019-20
T_1. Control	18.93	18.89	35.73	35.68
T_2. 75%RDN	19.36	19.40	36.21	36.25
T_3. 75% RDN+25% N-FYM	20.45	20.49	37.33	37.36
T_4. 75%RDN+25%N-VC	20.66	20.70	37.56	37.60
T_5. 75%RDN+25%N-FYM+S+Zn+Az.+PSB	23.53	23.58	40.68	40.73
T_6. 75%RDN+25%N-VC+S+Zn+Az.+PSB	23.78	23.83	40.96	41.02
T_7. 100%RDN	20.83	20.87	37.78	37.82
T_8. 100%RDN+S	20.95	20.99	37.93	37.97
T_9. 100%RDN+S+Zn	22.06	22.10	39.15	39.19
T_{10}. 100%RDN+S+Zn+Az.+PSB	23.93	23.97	41.15	41.20
T_{11}. 100%RDN+25%N –FYM	21.52	21.56	38.55	38.60
T_{12}. 100%RDN+25%-VC	21.68	21.72	38.73	38.77
T_{13}. 100%RDN+25% N-FYM+S+Zn+Az.+PSB	24.03	24.08	41.26	41.11
T_{14}. 100%RDN+25% N-VC+S+Zn+Az.+PSB	24.20	24.26	41.50	41.55
SE(m)	0.19	0.22	0.27	0.31
CD (5%)	0.54	0.63	0.78	0.90

Table.4 Effect of different treatments on N and P content in grain stover of maize

Treatments combinations	N content (%) Grain		N content (%) Stover		P content (%) Grain		P content (%) Stover	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1. Control	1.72	1.74	0.41	0.43	0.24	0.26	0.07	0.06
T_2. 75%RDN	1.75	1.78	0.46	0.49	0.26	0.29	0.11	0.10
T_3. 75% RDN+25% N-FYM	1.79	1.81	0.5	0.53	0.29	0.32	0.14	0.13
T_4. 75%RDN+25%N-VC	1.80	1.83	0.51	0.54	0.30	0.33	0.15	0.14
T_5. 75%RDN+25%N-FYM+S+Zn+Az.+PSB	1.90	1.94	0.60	0.64	0.38	0.42	0.23	0.22
T_6. 75%RDN+25%N-VC+S+Zn+Az.+PSB	1.91	1.95	0.61	0.65	0.39	0.43	0.24	0.23
T_7. 100%RDN	1.77	1.8	0.48	0.51	0.28	0.31	0.13	0.12
T_8. 100%RDN+S	1.81	1.84	0.52	0.55	0.31	0.34	0.16	0.15
T_9. 100%RDN+S+Zn	1.83	1.86	0.54	0.57	0.32	0.35	0.17	0.16
T_{10}. 100%RDN+S+Zn+Az.+PSB	1.87	1.91	0.57	0.60	0.37	0.41	0.22	0.21
T_{11}. 100%RDN+25%N –FYM	1.84	1.87	0.55	0.58	0.34	0.37	0.19	0.18
T_{12}. 100%RDN+25%-VC	1.85	1.88	0.56	0.59	0.35	0.38	0.20	0.19
T_{13}. 100%RDN+25% N-FYM+S+Zn+Az.+PSB	1.93	1.97	0.62	0.66	0.40	0.44	0.25	0.24
T_{14}. 100%RDN+25% N-VC+S+Zn+Az.+PSB	1.94	1.98	0.63	0.67	0.41	0.45	0.26	0.25
SE(m)	0.018	0.026	0.017	0.020	0.015	0.020	0.018	0.012
CD (5%)	0.054	0.067	0.050	0.058	0.044	0.058	0.053	0.034

Table.5 Effect of treatment on K and S content in grain and stover of maize

Treatments combinations	K content (%) Grain		K content (%) Stover		S content (%) Grain		S content (%) Stover	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1. Control	0.46	0.49	1.18	1.21	0.11	0.13	0.13	0.12
T_2. 75%RDN	0.48	0.51	1.21	1.24	0.13	0.15	0.16	0.14
T_3. 75% RDN+25% N-FYM	0.51	0.54	1.24	1.27	0.16	0.19	0.19	0.18
T_4. 75%RDN+25%N-VC	0.52	0.55	1.25	1.28	0.17	0.20	0.20	0.19
T_5. 75%RDN+25%N-FYM+S+Zn+Az.+PSB	0.60	0.64	1.34	1.38	0.27	0.31	0.30	0.28
T_6. 75%RDN+25%N-VC+S+Zn+Az.+PSB	0.61	0.65	1.35	1.39	0.28	0.32	0.31	0.29
T_7. 100%RDN	0.50	0.53	1.23	1.26	0.14	0.16	0.17	0.16
T_8. 100%RDN+S	0.53	0.56	1.26	1.29	0.20	0.23	0.23	0.22
T_9. 100%RDN+S+Zn	0.54	0.57	1.28	1.31	0.21	0.24	0.24	0.23
T_{10}. 100%RDN+S+Zn+Az.+PSB	0.59	0.62	1.33	1.37	0.26	0.30	0.28	0.28
T_{11}. 100%RDN+25%N –FYM	0.56	0.59	1.30	1.33	0.23	0.26	0.25	0.24
T_{12}. 100%RDN+25%-VC	0.57	0.60	1.31	1.34	0.24	0.27	0.26	0.25
T_{13}. 100%RDN+25% N-FYM+S+Zn+Az.+PSB	0.63	0.67	1.37	1.41	0.29	0.33	0.32	0.30
T_{14}. 100%RDN+25% N-VC+S+Zn+Az.+PSB	0.64	0.68	1.38	1.42	0.30	0.34	0.33	0.31
SE(m)	0.015	0.018	0.028	0.032	0.017	0.20	0.020	0.013
CD (5%)	0.045	0.054	0.081	0.094	0.049	0.058	0.059	0.037

Table.6 Effect of treatments in Zn content of grain and stover of maize

Treatments combinations	Zn content (mg kg^{-1}) Grain		Zn content (mg kg^{-1}) Straw	
	2018-19	2019-20	2018-19	2019-20
T_1. Control	37.70	37.73	8.93	8.95
T_2. 75%RDN	38.22	38.26	9.45	9.49
T_3. 75% RDN+25% N-FYM	39.15	39.19	10.88	10.37
T_4. 75%RDN+25%N-VC	39.18	39.22	11.05	11.54
T_5. 75%RDN+25%N-FYM+S+Zn+Az.+PSB	41.35	41.40	13.85	13.90
T_6. 75%RDN+25%N-VC+S+Zn+Az.+PSB	41.50	41.55	14.03	14.08
T_7. 100%RDN	38.66	38.70	9.88	9.92
T_8. 100%RDN+S	39.45	39.49	11.82	11.86
T_9. 100%RDN+S+Zn	40.78	40.82	12.77	12.81
T_{10}. 100%RDN+S+Zn+Az.+PSB	41.13	41.18	13.60	13.65
T_{11}. 100%RDN+25%N –FYM	40.25	40.29	12.15	12.19
T_{12}. 100%RDN+25%-VC	40.29	40.33	12.18	12.22
T_{13}. 100%RDN+25% N-FYM+S+Zn+Az.+PSB	42.03	42.08	14.60	14.65
T_{14}. 100%RDN+25% N-VC+S+Zn+Az.+PSB	42.21	42.26	14.82	14.87
SE(m)	0.46	0.62	0.31	0.35
CD (5%)	1.34	1.80	0.90	1.01

Potassium content

The highest K content (grain and straw) was noted with the application of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) however showed at par effect with the treatments of T_{13} (100% RDN+25% N-FYM+S+Zn+Az+PSB), T_6 (75% RDN+25% N-VC+S+Zn+Az+PSB) and T_5 (75% RDN+25% N-FYM+S+ Zn+Az+PSB) but had numerically higher. The K content and its uptake by grain and straw were influenced significantly with the application of different treatments in maize. In general, the K content was recorded higher in straw than grain. The results are in close conformity with the findings of (Vasanthy and Kumaraswamy 2000). The increased uptake of K by wheat may be ascribed to the release of K from the K-bearing minerals by complexing agents and organic acids produced during decomposition of organic sources (Sharma *et al.*, 2013). Available K in soil increased with the application of organic manures because of its solubilising action of organic acids produced during FYM decomposition and its higher capacity to hold K in available form thereby improving K use efficiency in plants (Vidyavathi *et al.*, 2011).

Sulfur content

The data regarding S content have been presented in table 5.0. The application of S in *kharif* significantly improved the S content and in grain and straw of wheat as compare to treatments where S was not applied. The highest S content was recorded with the treatment of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) which remained statistically on par with T_{13} (100% RDN+25%

N-FYM+S+Zn+Az+PSB), T_6 (75% RDN+ 25% N-VC+S+Zn+Az+PSB) and T_5 (75% RDN+25% N-FYM+S+Zn+Az+PSB) and significantly superior to rest of the treatments. It was also observed that the application of S in combination with FYM or VC further increased the S content in grain. The results are in agreement with the findings of Srivastava *et al.,* (2015). The response of wheat to applied S in preceding maize crop may be attributed to an enhanced availability of S in soil Singh and Pandey (2018). The build-up of sulphate S content in soil due to use of FYM either alone or in combination with NPK was reported by Singh *et al.,* (1999) The similar results also reported by Manna *et al.,* (2006).

Zinc content

The applied Zn in *kharif* markedly improved its content in succeeding wheat crop. The maximum Zn content was recorded with the treatment of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) which was numerically higher to all the treatments however, remained statistically at par with T_{13} (100% RDN+25% N-FYM+S+Zn+Az+PSB), T_6 (75% RDN+ 25% N-VC+S+Zn+Az+PSB) and T_5 (75% RDN+25% N-FYM+S+Zn+Az+PSB) during both the years of experimentation. These results are in close conformity with the findings of Faujdar and Sharma (2013) and Joshi *et al.,* (2013).

Well decomposed FYM and Vermicompost might have involved in formation of chelates with organic ligands which might have lowered susceptibility to adsorption, fixation and precipitation in the soil and also it was attributed to mineralization of organic manures and consequent release of micronutrients Vidyavathi *et al.,* (2012). The highest concentration of nutrients in maize and wheat were recorded with the application of T_{14} (100% RDN+25% N-VC+S+Zn+Az+PSB) but remained statistically at par with the treatments of T_{13} where FYM was given instead of VC with respect to all the nutrients including NPKS Zn. It was noticed that the integration of VC/FYM along RDN with or without S, Zn, Az and PSB found optimum from nutrient accumulation point of view. The further addition of 25 % N through VC/FYM along 100% RDN proved beneficial in terms of nutrient concentration in grain and stover of maize and wheat.

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