

# Effect of Zinc and Biofertilizer on Changes in Soil Fertility Status under Hybrid Rice – Chickpea Cropping Sequence in Alluvial Soils of Central Uttar Pradesh

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## Authors' contributions

*This work was carried out in collaboration among all authors. Author NK designed the whole study, conducted the field work and data collection and performed the statistical analysis. Authors RP, AKS and SD helped in data collection, managed the analysis of the study and literature searches. All authors read and approved the final manuscript.*

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## ABSTRACT

**Aims:** The present study was conducted to investigate the changes in soil fertility status with the application of zinc and biofertilizers in hybrid rice and chickpea.

**Study Design:** The design taken for study was Randomized Block Design (RBD).

**Place and Duration of Study:** Students Instructional Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur, Uttar Pradesh, between July 2018 – July – 2020.

**Methodology:** The experiment included twelve treatment groups replicated three times in Randomized Block Design.

**Results:** Soil parameters were also influenced with the application of zinc and biofertilizer. The available nitrogen varied between 192 to 223 kg ha<sup>-1</sup> and 191 to 222 kg ha<sup>-1</sup> at after harvest during

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first and second year in case of rice crop. The available phosphorus in case of rice was varied between 11.82 to 11.88 kg ha<sup>-1</sup> at before harvest and 11.75 to 13.65 kg ha<sup>-1</sup> at after harvest during first year. In case of available potassium it varied from 169 to 173 kg ha<sup>-1</sup> at before harvest of the crop and 169 to 185 kg ha<sup>-1</sup> at after harvest during first year. Similarly, significant increase in sulphur and zinc was also observed with application of zinc and biofertilizers. The available nitrogen, phosphorus potassium, sulphur and zinc were analysed numerically highest with the application T<sub>7</sub> (100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium) as compared to control at before and after harvest the crop during both the years that is 2018-19 and 2019-20. Similar trend was seen in case of chickpea crop.

**Conclusion:** Therefore, the combination of micronutrients and biofertilizers, proved beneficial, indicating to use balanced fertilizers to get maximum benefit and maintaining soil health in rice-chickpea cropping system for the farmers of Central Uttar Pradesh conditions.

**Keywords:** Hybrid rice; chickpea; micronutrients; nutrient uptake and soil fertility status.

## 1. INTRODUCTION

India occupies largest among the rice grown countries and ranks second in production after China. In the Asian region about 90 per cent of rice grown in world is produced and consumed. India produces 116.42 million tonnes of rice from an area of 43.38 million hectares with a productivity of 2550 kg ha<sup>-1</sup> (2018-19). Seventy districts of Uttar Pradesh are known to cultivate rice crop under an area of 5.86 million hectares with a production of 12.51 million tonnes and having productivity of 2 t ha<sup>-1</sup>. (2018-19). Chickpea (*Cicer arietinum* L.) is also the most important pulse crop of India, because it is grown under varying soil and climatic conditions and also in soils of low fertility condition. In India, chickpea occupies an area of about 8.32 million ha with an annual production of 10.13 million tonnes and productivity of 851 kg ha<sup>-1</sup> (2018-19). Uttar Pradesh also cultivate chickpea under an area of 589 hectares with a production of 596.70 tonnes and having productivity of 1013 kg ha<sup>-1</sup> (2018-19).

However imbalanced chemical fertilization and improper use of pesticides have resulted in fast soil degradation and deficiency of micronutrients, deterioration of soil physical properties, properties of land and water and health hazards to animal and human. Further, limited use of organics and absence of proper recycling of crop residues has also further added to deficiency symptoms under this system of rice cultivation.

Biofertilizers are cost effective, eco friendly and renewable sources of plant nutrients to supplement or complement chemical fertilizers and helps in maintaining long term fertility and sustainability.

Thus, to achieve higher yields and also to overcome micronutrient deficiencies, proper dose and method of application of these micronutrients becomes most relevant. Since these micronutrients are essential for proper metabolic and physiological activities of plant they enhance crop yields. Application of beneficial micro – organisms is known to help in mineralization and mobilization of macro and micronutrients needed by the crop. The yield levels of chickpea have been generally low which might be attributed to its major cultivation under rainfed conditions with less/imbalance use of fertilizers, limited seed inoculation (10% approximately) with *Rhizobium* and phosphorus solubilizing bacterial cultures [1] and also due to its susceptibility to wilt, insect, pest and diseases.

Productivity can be enhanced by growing improved varieties and by following proper agronomic management practices. As far as nutrient requirement of chickpea is concern a dose of 20 kg N, 50 kg P<sub>2</sub>O<sub>5</sub>, 20 kg K<sub>2</sub>O and 20 kg S is recommended in chickpea. Application of 20 kg N/ha serve as a starter dose to meet out the nitrogen requirement of chickpea at initial stage till the formation of active nodules and start of Biological Nitrogen Fixation (BNF).

Hence, supplementation of micronutrients (Zn and Mo) and organic/inorganic sources of nutrients along with *Rhizobium* inoculation in chickpea cultivation may increase biological nitrogen fixation, P availability to this crop and thereby its productivity.

Therefore, suitable combination of chemical fertilizers, organic manures zinc and biofertilizers need to be developed for particularly rice – chickpea is predominant under irrigated

production system. Hence, the present study was undertaken to investigate the response of paddy and chickpea to zinc and biofertilizers.

## 2. MATERIALS AND METHODS

A field experiment was conducted at Students Instructional Farm, Kanpur Nagar, at Chandra Shekhar Azad University of Agriculture and Technology, Kanpur during the crop growing period 2018-19 and 2019-20 which is of 25°26' and 26°58' north latitude and 79°31' and 80°34' East longitude with an elevation of 125.9 m from sea level in the alluvial belt of Indo- gangetic plains of central Uttar Pradesh. The soils of experimental site was sandy clay loam in texture and saline in reaction having pH value of 8.40 and organic carbon of 0.45 per cent. The amount of available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O were 190.00, 11.80 and 170.00 kg ha<sup>-1</sup>, respectively. The soil is deficient in available sulphur 12.54 kg ha<sup>-1</sup> and DTPA extractable zinc 0.40 mg g<sup>-1</sup>. The experiment was laid out in Randomized Block Design with twelve treatments and three replications. The treatments consist of T<sub>1</sub> = Control, T<sub>2</sub> = 125 per cent RDN, T<sub>3</sub> = 100 per cent RDN, T<sub>4</sub> = 100 per cent RDN + 25 per cent N FYM, T<sub>5</sub> = 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub>, T<sub>6</sub> = 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO, T<sub>7</sub> = 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium, T<sub>8</sub> = 75 per cent RDN, T<sub>9</sub> = 75 per cent RDN + 25 per cent N FYM, T<sub>10</sub> = 75 per cent RDN + 25 per cent N FYM + S<sub>40</sub>, T<sub>11</sub> = 75 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO, T<sub>12</sub> = 75 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium. The seedlings are uprooted from the nursery at the optimum age. Transplanting may be done at the 4 to 5 leaf stage. Before transplanting seedlings of respective treatments were inoculated with biofertilizer slurry. In Hybrid rice Half dose of N and full dose of P, K, S and Zn were applied just before transplanting. Rest quantity of N was applied in two split doses in standing crop at tillering and panicle initiation stage respectively and in case of Chickpea Nitrogen, phosphorus and potash were applied as basal dressing in all plots. Diammonium phosphate applied as source of nitrogen and phosphorus, potassium was applied through muriate of potash as basal dose. Sulphur and zinc were also applied as basal dressing as per treatment through elemental sulphur and zinc respectively. All the management practices as suggested in the package of practice of CSAUA&T, Kanpur were adopted. The data were subjected to analysis of variance analysis

(ANOVA) using CoStat computer software package.

## 3. RESULTS AND DISCUSSION

### 3.1 Available Nitrogen

The available nitrogen presented the data in Table 1 varied between 192 to 223 kg ha<sup>-1</sup> at after harvest of the crop during first year and 191 to 222 kg ha<sup>-1</sup> at after harvest during second year in case of rice crop. In case of chickpea the available nitrogen content was varied between 216 to 222 kg ha<sup>-1</sup> at before harvest and 214 to 235 kg ha<sup>-1</sup> at after harvest during first year. In general, the available nitrogen increases with increasing doses of fertilizer. The available nitrogen was analysed numerically and gave the highest value with the application T<sub>7</sub> (100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium) as compared to control at before and after harvest of the crop. These results are in agreement with the findings of [2] and [3].

### 3.2 Available Phosphorus

The available phosphorus increases with increasing dose of fertilizer and it ranged in case of rice was varied between 11.82 to 11.88 kg ha<sup>-1</sup> at before harvest and 11.75 to 13.65 kg ha<sup>-1</sup> at after harvest during first year Table 1. The available phosphorus was analysed numerically highest with the application T<sub>7</sub> (100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium) as compared to control at before and after harvest the crop. Similar trend was seen in case of chickpea crop. It might be due to favourable effect of zinc and biofertilizer added by Azotobacter in case of rice and Rhizobium in case of chickpea which improved all soil properties. It also may be due to the application of zinc improved the physico-chemical properties of soil, increased the root nodules and also due to addition of microbial residues. The findings are close in association with findings of [4] and [5].

### 3.3 Available Potassium

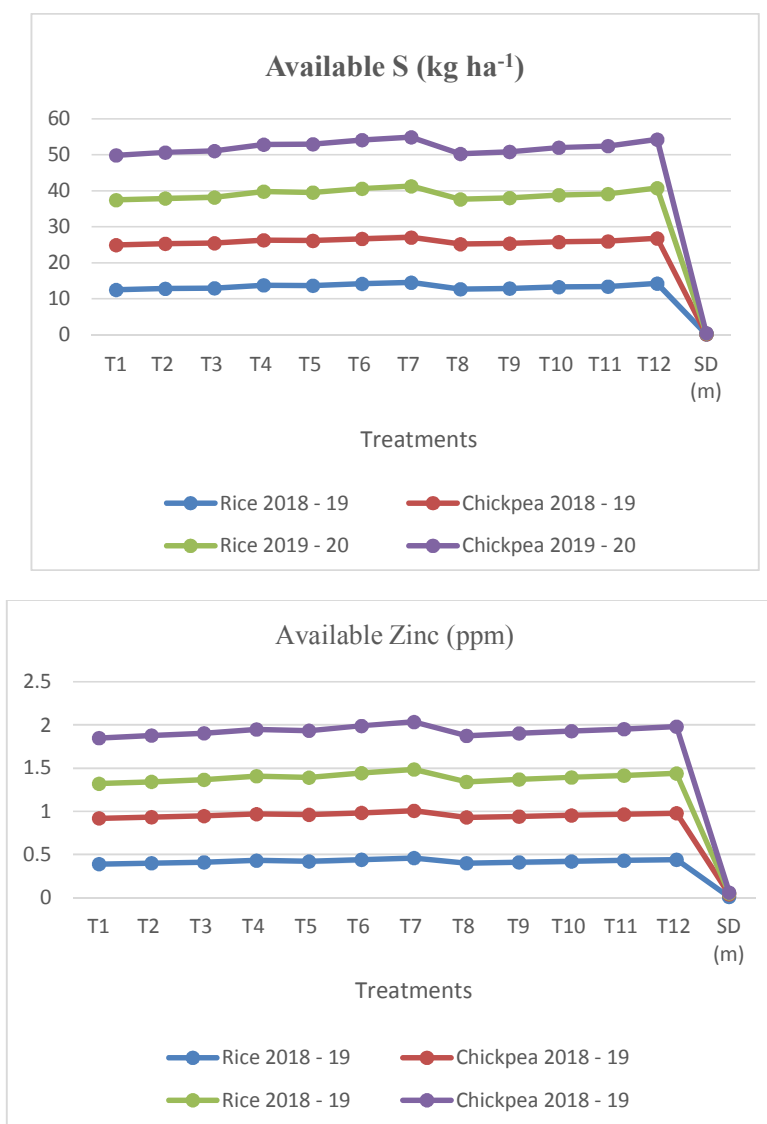
The status of available potassium before and after harvest of the crop was significantly influenced by the imposed treatments Table 2. The available potassium varied between 169 to 174 (kg ha<sup>-1</sup>) at before harvest and 169 to 185 (kg ha<sup>-1</sup>) at after harvest during first year in case of rice. In chickpea the available potassium

**Table 1. Effect of zinc nutrition and biofertilizer on soil available nitrogen, phosphorus and potassium in rice and chickpea**

Treatments	Av. N (kg ha <sup>-1</sup> )						Av. P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )						Av. K <sub>2</sub> O (kg ha <sup>-1</sup> )					
	Rice			Chickpea			Rice			Chickpea			Rice			Chickpea		
	Before 2018-19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018- 19	After 2019- 20
T <sub>1</sub> = Control	195	192	191	216	214	219	11.82	11.75	12.72	13.61	13.35	13.55	169	169	170	142.30	143.75	142.35
T <sub>2</sub> = 125 per cent RDN	188	197	196	218	220	226	11.83	12.06	13.06	13.62	13.50	13.80	171	173	174	143.40	145.65	147.22
T <sub>3</sub> = 100 per cent RDN	192	199	198	219	224	230	11.85	12.18	13.19	13.65	13.65	13.95	172	175	176	145.65	149.40	151.01
T <sub>4</sub> = 100 per cent RDN + 25 per cent N FYM	190	202	201	217	226	232	11.87	12.36	14.03	13.60	13.85	14.16	168	177	177	141.90	151.35	152.98
T <sub>5</sub> = 100 per cent RDN + 25 per cent 47.92N FYM + S <sub>40</sub>	193	210	209	218	229	235	11.85	12.85	13.92	13.66	14.15	14.46	172	182	183	145.30	153.15	154.80
T <sub>6</sub> = 100 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO	195	218	217	222	232	238	11.84	13.34	14.44	13.62	14.75	15.08	169	184	185	140.80	155.10	156.77
T <sub>7</sub> = 100 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO + *Azotobacter or **Rhizobium	193	223	222	223	235	244	11.88	13.65	14.78	13.63	15.80	16.15	173	185	186	146.65	157.65	159.35
T <sub>8</sub> = 75 per cent RDN	188	195	194	223	212	221	11.90	11.93	12.91	13.64	13.40	13.70	168	171	172	144.40	144.30	145.86
T <sub>9</sub> = 75 per cent RDN + 25 per cent N FYM	188	198	197	224	226	223	11.89	12.12	13.12	13.67	13.40	13.71	170	174	174	146.65	142.90	144.45
T <sub>10</sub> = 75 per cent RDN + 25 per cent N FYM + S <sub>40</sub>	189	204	203	221	221	227	11.85	12.48	13.51	13.70	13.50	13.80	171	179	180	145.90	145.35	146.92
T <sub>11</sub> = 75 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO	191	206	205	224	223	229	11.90	12.61	13.65	13.75	13.80	14.11	172	181	182	144.10	148.40	150.01
T <sub>12</sub> = 75 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO + *Azotobacter or **Rhizobium	193	219	218	223	228	234	11.91	13.40	14.51	13.80	14.90	15.23	171	183	184	142.95	150.65	152.27
C.D.	N.S.	5.86	5.37	N.S.	12.18	10.03	N.S.	0.39	0.35	N.S.	0.36	0.43	N.S.	4.92	5.15	N.S.	4.18	2.16
SE (m)	2.50	1.99	1.83	5.08	4.15	3.41	0.21	0.13	0.11	0.18	0.12	0.14	1.58	1.67	1.75	2.24	1.42	0.74
SE (d)	3.53	2.82	2.59	7.19	5.87	4.83	0.29	0.18	0.17	0.26	0.17	0.21	2.24	2.37	2.48	3.17	2.01	1.04

**Table 2. The nutrient status of postharvest soil affected by rice and chickpea cultivation with zinc fertilizer and biofertilizer**

Treatments	Av. S (kg ha <sup>-1</sup> )						Av. Zn (ppm)					
	Rice			Chickpea			Rice			Chickpea		
	Before 2018- 19	After 2018-19	After 2019- 20	Before 2018-19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018- 19	After 2019- 20	Before 2018- 19	After 2018-19	After 2019-20
T <sub>1</sub> = Control	12.54	12.51	12.50	12.49	12.45	12.43	0.39	0.39	0.40	0.533	0.530	0.529
T <sub>2</sub> = 125 per cent RDN	12.55	12.84	12.59	12.60	12.49	12.74	0.40	0.40	0.41	0.534	0.533	0.536
T <sub>3</sub> = 100 per cent RDN	12.56	12.97	12.71	12.50	12.51	12.90	0.41	0.41	0.42	0.536	0.536	0.539
T <sub>4</sub> = 100 per cent RDN + 25 per cent N FYM	12.55	13.80	13.52	12.53	12.50	13.05	0.40	0.43	0.44	0.531	0.538	0.541
T <sub>5</sub> = 100 per cent RDN + 25 per cent 47.92N FYM + S <sub>40</sub>	12.57	13.68	13.41	12.54	12.47	13.41	0.41	0.42	0.43	0.535	0.541	0.544
T <sub>6</sub> = 100 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO	12.58	14.20	13.92	12.51	12.49	13.52	0.43	0.44	0.46	0.532	0.543	0.546
T <sub>7</sub> = 100 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO + *Azotobacter or **Rhizobium	12.60	14.53	14.24	12.52	12.53	13.61	0.44	0.46	0.48	0.534	0.546	0.549
T <sub>8</sub> = 75 per cent RDN	12.56	12.70	12.45	12.53	12.51	12.63	0.41	0.40	0.41	0.535	0.531	0.534
T <sub>9</sub> = 75 per cent RDN + 25 per cent N FYM	12.55	12.90	12.64	12.51	12.49	12.83	0.42	0.41	0.43	0.533	0.530	0.533
T <sub>10</sub> = 75 per cent RDN + 25 per cent N FYM + S <sub>40</sub>	12.57	13.29	13.02	12.52	12.52	13.20	0.43	0.42	0.44	0.535	0.533	0.536
T <sub>11</sub> = 75 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO	12.59	13.43	13.16	12.54	12.55	13.34	0.41	0.43	0.45	0.536	0.535	0.538
T <sub>12</sub> = 75 per cent RDN + 25 per cent N FYM + S <sub>40</sub> + ZnO + *Azotobacter or **Rhizobium	12.58	14.27	13.98	12.55	12.53	13.49	0.43	0.44	0.46	0.533	0.539	0.542
C.D.	N.S.	0.49	0.61	N.S.	0.16	0.25	N.S.	0.02	0.03	N.S.	0.09	0.09
SE (m)	0.23	0.16	0.21	0.15	0.05	0.08	0.01	0.01	0.01	0.26	0.03	0.01
SE (d)	0.32	0.24	0.29	0.21	0.08	0.12	0.02	0.01	0.01	0.37	0.04	0.01



**Fig. 1. Effect of zinc and biofertilizers on available sulphur and zinc on rice and chickpea**

ranged was varied between 142.30 to 146.65 (kg ha<sup>-1</sup>) at before harvest and 143.75 to 157.65 (kg ha<sup>-1</sup>) at after harvest during first year. The available potassium increase with increasing doses of fertilizer. The available potassium was analysed numerically highest with the application of 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium in T<sub>7</sub> treatment as compared to control at before and after harvest the crop. Increase in available potassium status of soil could be ascribed to greater capacity of organic colloids to hold the nutrients at the exchange site and also reduction of potassium fixation and release of potassium to the available pool of soil due to

application of organics along with fertilizers. The work is in close association with the findings of [6] and [7].

### 3.4 Available Sulphur

It is perusal from data depicted in Table 2 and Fig. 1 that available sulphur in rice was ranged from 12.54 to 12.60 (kg ha<sup>-1</sup>) at before harvest and 12.51 to 14.53 (kg ha<sup>-1</sup>) at after harvest during first year under control to 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium in T<sub>7</sub> treatment. The available sulphur was analysed numerically the highest value was found with the application of

100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium in T<sub>7</sub> treatment as compared to after harvest the crop. Similar trend was obtained in chickpea as well. This might be due to their release through mineralization of organic sources which have the ability to reduce their adsorption, fixation and precipitation resulting in their enhanced availability in soil. The results are in close association with [8].

### 3.5 Available Zinc

The available zinc in rice varied between 0.39 to 0.44 ppm at before harvest and 0.39 to 0.46 ppm at after harvest during first year under control to 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium in T<sub>7</sub> treatment Table 2 and Fig. 1. In general, the available zinc increases with increasing doses of fertilizer. In chickpea the available zinc ranged was varied between 0.530 to 0.546 ppm at after harvest during first year under control to 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium in T<sub>7</sub> treatment. The available zinc in rice and chickpea was analysed numerically highest with the application of 100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium in T<sub>7</sub> treatment as compared to control at before and after harvest the crop. The findings are in close conformity with the works of [9].

### 4. CONCLUSION

The results from the two growing seasons (2018-19 and 2019-20) concluded that the soil fertility status increased with application of zinc and biofertilizer (Azotobacter in case of rice and Rhizobium in case of chickpea) in both rice and chickpea. Treatment T<sub>7</sub> (100 per cent RDN + 25 per cent N FYM + S<sub>40</sub> + ZnO + \*Azotobacter or \*\*Rhizobium) showed maximum amount of nutrient availability. Hence, this combination of micronutrients and biofertilizers, proved as remunerative and beneficial indicating to use balanced fertilizers to get maximum benefit and maintaining soil health in rice-chickpea cropping system for the farmers of Central Uttar Pradesh conditions.

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### COMPETING INTERESTS

Authors have declared that no competing interests exist.

### REFERENCES

1. Sharma HO, Gupta SC. Yield of chickpea under rainfed condition with less/imbalance use of fertilizer with Rhizobium and PSB culture. Indian Journal Pure and Applied Biology. 2005;20: 197-204.
2. Rasod FR, Hasan B, Jahangir IA, Mubarak T. Nutritional yield and economic responses of sunflower (*Helianthus annuus L.*) to integrated levels of nitrogen, Sulphur and farmyard manure. Journal of Agricultural Sciences. 2013;8(1):17-27.
3. Sahu G, Chatterjee N, Ghosh GK. Integrated nutrient management in rice (*Oryza sativa*) in red and laterite soils of west Bengal. Indian Journal of Economy. 2017;44:349-354.
4. Chavan RS. Effect of zinc application on utilization of nutrient uptake, yield and quality of chickpea in inceptisol. Unpub. M. Sc (Agri);Thesis, Dr. PDKV, Akola; 2015.
5. Yadav D, Shivay YS, Singh YV, Sharma VK, Bhatia A. Water use and Soil Fertility under Rice – wheat Cropping system in response to green manuring and zinc nutrition. Communications in Soil Science and Plant Analysis. 2019;50(22):2836–2847.
6. Hossain M, Jahiruddin M, Moslehuddin AZ, Islam MR. Optimization of zinc and boron doses for cauliflower- maize – rice pattern in floodplain soil. Communications in Soil Science and Plant Analysis. 2019;50(12):1425–1438.
7. Singh AK, Meena MK, Upadhyay A. Effect of S and Zn on rice performance and nutrient dynamics in plant and soils of Indo gangetic plains. Journal of Agricultural Sciences. 2012;4:11.
8. Rathod DD, Meena MC, Patel KP. Evaluation of different zinc enriched organics as source of zinc under wheat-maize cropping system on zinc deficient Typic. Journal of Indian Society of Soil Science. 2012;60(1):50-55.

9. Suganya A, Saravanan A. DTPA- zinc levels of zinc in combination with in soil under simulated moisture zinc solubilizing bacteria. Trends conditions as influenced by graded in Biosciences. 2014;7(23):3968-3971.

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