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Response of sulphur and zinc nutrients on nutrient uptake in maize and wheat crop and effect of various treatments on quality of maize-wheat cropping system

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Abstract
As investigation was carried out during 2018-19 and 2019-20 at Student Instructional Farm, Department of Agronomy, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur with main objective to find out the technically feasible, qualitative, productive and economically viable effect of Sulphur and Zinc maize-wheat cropping rotation and to evaluate the response of these treatments on maize-wheat cropping system. The soil of university research farm is an Entisol with sandy loam texture, deficient in organic carbon available N and available Zn but medium in case of available P, K and available S. The pH and EC of soil are in normal range and responsive to macro and micro nutrients applied in balanced manner in view of the deficiency of these nutrients and vital metabolic role of the above nutrients in maize-wheat cropping system and studied in respective manners. Effect of different inorganic sources as 9 treatments comprises of *viz.*, T_1 - Control, T_2- 50% NPK, T_3- 100% NPK, T_4- 50% NPK + S, T_5- 100% NPK + S, T_6- 50% NPK + Zn, T_7 -100% NPK + Zn, T_8 - 50% NPK + S + Zn and T_9 - 100% NPK + S + Zn. Results recorded significantly highest N content was in T_9 whilst lowest in T_1 (control) during course of investigation. The maximum protein content was noted with the application of T_9 (100% RDF+S+Zn) respectively. The data clearly indicated that addition of Sulphur and Zinc significantly enhanced the protein content during first and second year respectively. However the maximum content was noted with the application of T_9 (100% RDF+S+Zn) but remained at par with T_5 (100% RDF+S) and T_7 (100% RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. The graded application of RDF from 50 to 100% has further increased the concentration of protein. The maximum protein value content was noted with the application of T_9 (100% RDF+S+Zn). The data clearly indicated that addition of Sulphur and Zinc enhances the protein content significantly the first and second year respectively. But remained at par with T_5 (100% RDF+S) and T_7 (100% RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis during course of investigation.

Keywords: control, T_2- 50% NPK, T_3- 100% NPK, T_4- 50% NPK + S, T_5- 100% NPK + S, T_6- 50% NPK + Zn, T_7 -100% NPK + Zn, T_8 - 50% NPK + S + Zn and T_9 - 100% NPK + S + Zn

Introduction
Wheat (*Triticum aestivum* L.), another major staple cereal, supplies the bulk of calories and nutrients in the diets of a large segment of the world about 11.9 per cent of the world's wheat production from around 12 per cent of the world's area (Singh *et al*., 2010) [29] Population. Maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.) are belonging to family Poaceae is the most dominant cropping system in the Uttar Pradesh. Its straw is used as food for a large population of cattle in the world. It contains about 8-15% protein as glutein. India covers about 32 per cent of the total area under cereals in the world. It is the second largest wheat producing nation in the world contributing about 1/9th of the global wheat production. In our country, wheat is grows in 26.6 million hectares area with the production of 73.0 m tones (Anonymous 2005). Winter and spring wheat are the two primary types of crops, with the intensity of winter deciding whether winter or spring is grown. The largest wheat growing regions in the world are China, India, United States, Russian Federation, France, Australia, Germany, Ukraine, Canada, Turkey, Pakistan, Argentina, Kazakhstan and United Kingdom (FAO, 2003). Popular wheat or bread wheat (*Triticum astivum* L.) - one of the hexaploid plants grown in small amounts. It is an ancient grain type; it refers to a historical region in modern-day Afghanistan and the northeast of Iran. This grain is twice the size of modern- day wheat is known for the rich nutty flavour diploid species. Domesticated at the same time as (long established species of wheat with bearded ears and spikelet's that contains two grains) emmer wheat, but never had the same importance. Although most wheat is grown for human food and about only 10 percent is retained for seed industry (for production of starch, paste, malt, dextrose, gluten).

Maize-wheat crop rotation is one of the major cropping systems adopted in India, covering around 1.8 million hectares area that contributes 3% food grain production in India, mainly in the Indo-Gangetic plains of the country. Fertile revenue alluvial soils are best for Maize-wheat cultivation. Among different maize based cropping systems, maize-wheat rank first and it is third most important cropping system after rice-wheat and rice-rice. Maize and wheat are the main source of food energy in the world and also contain significant amounts of carbohydrates, proteins, vitamins and minerals that are essential to human health. It is, considered to be the most important option for diversifying agriculture in the upland ecology of India. Maize being a C4 plant species has a high production potential compared to any other cereal crop.

It occupies an important position in the world economy and trade as a food, feed and industrial grain crop (Lal 2001) In India, maize is grown in an area of 9.0 million hectares with a production of 26,14 million tons and a productivity of 2629,28 kg ha^{-1} (Government of India, 2018). Ten states in India represents around 80% of the total area of maize grown, Karnataka (15%) is the largest state for maize cultivation followed by Rajasthan (13%) and Madhya Pradesh (10%). The maize-wheat crop system ranks first among the various maize-base farming systems *(*Jat *et al.,* 2011). The balanced fertilization is a key component of nutrient management and plays a key role in improving crop production. The balanced application of nutrients such as N, P, K, S and Zn etc. is essential for major processes of plant development and yield formation; (Randhwa and Arora 2000) [25]. Among the micronutrients Zinc is the most important and is deficient to the extent of about 49% alluvial soils. Balanced application of these nutrients provides sustainability in yield and improving nutritional quality of the crop. It is because of the key metabolic role of these nutrients in crops the importance of the nutrients warrant some elaboration in the present context. Zinc (Zn) is an essential trace element for the growth and development of humans, animals and plants. Soil Zn application to Zn-deficient soil corrected the visible symptoms of Zn deficiency and significantly increased the total biomass, grain yield, harvest index as well as Zn concentrations of grain and straw (Srivastava *et al.,* 1999), increased maize grain yield by more than 22% and enhanced the Zn and N concentrations in maize grain (Hossain *et al*., 2008).

Materials and Methods:

The experiment was conducted at Students' Instructional Farm, Department of Agronomy Chandra Shekhar Azad University of Agriculture & Technology, Kanpur and itwas in the alluvial tract of Indo - Gangetic plains in central part of Uttar Pradesh 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 irrigation facilities are available on the farm. This zone has semi-arid climatic conditions, having alluvial fertile soil. The normal rainfall of the area is about 890 mm per annum. Most of the rains are received from mid-June to end of September.. Maize was grown during kharif which was followed by wheat during *rabi* of 2018-19 and 2019- 2020 with a view to compare production potential of maize and wheat under management of RDF through the use of inorganic fertilizers, on wheat crop to find out the economic viability of the system under irrigated conditions of Central Uttar Pradesh.The experimental details are given below: The experiment was carried out in Randomized Block Design (RBD) having three replications and nine integrated nutrient management combinations *i.e.* T_1 Control, T_2 50% NPK, T_3 100% NPK, T_4 50% NPK + S, T_5 100% NPK + S, T_6 50% NPK + Zn, T_7 100% NPK + Zn, T_8 50% NPK + S + Zn and T_9 100% NPK + S + Zn.

Results and Discussion

Maize Crop

Effect of inorganic sources on content and uptake of nutrients in both grain and stover of maize crop during 2018-19 and 2019-20 were analyzed statistically the results of both years have been presented in Table-1.

Nitrogen content (%) in grain and stover

As shown in table 1 the data revealed that the application of different treatments in maize had significant influence on N content in both grain and stover of maize during both the years. The N content in grain ranged from 1.29 to 1.54% and 1.30 to 1.55 during first and second years, respectively. The graded application of RDF from 50 to 100% has further increased the concentration of nitrogen. The maximum N content was noted with the application of T_9 (100% RDF+S+Zn) but remained at par with T_5 (100%RDF+S) and T_7 (100%RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. The similar pattern was also observed with respective to N content in stover of maize ranging from 0.49 to 0.58% and 0.50 to 0.60% during first and second years, respectively. The highest N content was in T_9 whilst lowest in T_1 (control) during course of investigation. The similar results were reported earlier by Singh *et al.,* (2010) [29], Naresh *et al.* (2014) [23], Kumar and Bohra (2014) [18] and Kumar *et al.* (2017) [21].

Protein content (%)

As shown in table 1 the data revealed that the application of different treatments in maize had significant influence on Protein content in grain of maize during both the years. The protein content in grain ranged from 8.15 to 8.40 and 8.18 to 8.75 during first and second years, respectively. The graded application of RDF from 50 to 100% has further increased the concentration of protein. The maximum protein content was noted with the application of T_9 (100% RDF+S+Zn). The data clearly indicated that addition of Sulphur and Zinc significantly enhanced the protein content during first and second year respectively. However, remained at par with T_5 (100%RDF+S) and T_7 (100%RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. The control gave the lowest value of protein during first and second year of experimentation. Similar findings were observed by Sinha *et al.,* (1995) maize (Sakal *et al.,* 2000) and Blumenthal *et al*., 2008.

Table 1: Effect of different inorganic treatments on Nitrogen content (%) in grain and straw and Protein content (%) of maize during 2018-19 and 2019-20

Treatments combinations	Nitrogen content (%)in grain			N content (%) in stover			Protein content (%)		
	2018-19	2019-20	Pooled Mean	2018-19	2019-20	Pooled Mean	2018-19	2019-20	Pooled Mean
T_1 Control	1.29	1.30	1.29	0.490	0.500	0.495	8.15	8.18	8.16
T_2 50% NPK	1.37	1.38	1.37	0.520	0.530	0.525	8.21	8.25	8.22
T_3 100 NPK	1.43	1.45	1.44	0.540	0.550	0.545	8.27	8.31	8.29
T_4 50% NPK+S	1.41	1.42	1.41	0.530	0.540	0.535	8.21	8.25	8.24
T_5 100% NPK +S	1.51	1.53	1.52	0.570	0.580	0.575	8.36	8.40	8.38
T_6 50% NPK + Zn	1.39	1.40	1.39	0.530	0.540	0.535	8.23	8.27	8.25
T_7 100% NPK + Zn	1.49	1.51	1.50	0.560	0.580	0.570	8.33	8.37	8.35
T_8 50% NPK + S + Zn	1.41	1.42	1.41	0.540	0.550	0.545	8.30	8.34	8.32
T_9 100% NPK + S + Zn	1.54	1.55	1.54	0.580	0.600	0.590	8.40	8.75	8.57
SE (d)	0.040	0.046	0.030	0.015	0.021	0.013	0.044	0.073	0.082
CD (0.05%)	0.086	0.098	0.061	0.034	0.046	0.027	0.087	0.154	0.167

Wheat Crop

Effect of inorganic sources on content and uptake of nutrients in both grain and stover of ***wheat crop*** *during 2018-19 and 2019-20 were analyzed statistically the results of both years have been presented in Table-2*

4.4.1 Nitrogen content in grain (%)

As shown in table 2 the data revealed that the application of different treatments in maize had significant influence on N content in both grain and straw of wheat during both the years. The N content in grain ranged from 1.71to 1.83 and 1.70 to 1.84 during first and second years, respectively. The graded application of RDF from 50 to 100% has further increased the concentration of nitrogen. The maximum content was noted with the application of T_9 (100%RDF+S+Zn) but remained at par with T_5 (100%RDF+S) and T_7 (100%RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. Similar findings were observed by Keram *et al.* (2012), Singh *et al.*, (2010) [29], Yadav *et al*. (2005), Kapoor, *et al*. (2016) [15] and Kumar *et al*. (2017) [21].

Nitrogen content in straw (%)

The similar pattern was also observed in table 2 with respective to N content in straw of wheat ranging from 0.05 to 0.09% and 0.04 to 0.10% during first and second year respectively. The highest N content was in T_9 (100% RDF+S+Zn) whilst lowest in T_1 during course of investigation. The maximum content was noted with the application of T_9 but remained at par with T_5 (100%RDF+S) and T_7 (100%RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. The control gave the lowest value of protein during first and second year of experimentation.The control gave the lowest value of nitrogen content in straw during first and second year of experimentation. Similar findings were observed by Singh *et al.*, (2010) [29], Kumar *et al*. (2017) [21] and Yadav*et al*. (2005), Aut*iet al.* (1999), Kapoor, *et al*. (2016) [15].

Protein content in grain (%) of wheat

As shown in table 2 the data revealed that the application of different treatments in wheat had significant influence on Protein content in grain of wheat during both the years. The protein content in grain ranged from 10.80 to 11.45% and 10.82 to 11.48% during first and second years, respectively. The graded application of RDF from 50 to 100% has further increased the concentration of protein. The maximum protein value content was noted with the application of T_9 (100% RDF+S+Zn). The data clearly indicated that addition of Sulphur and Zinc enhances the protein content significantly the first and second year respectively. But remained at par with T_5 (100%RDF+S) and T_7 (100%RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. The control gave the lowest value of protein during first and second year of experimentation. Similar findings were observed by Singh *et al.*, (2010) [29], Kumar *et al*. (2017) [21].

Table 2: Effect of different inorganic treatments on Nitrogen content (%) in grain and straw and Protein content (%) of wheat during 2018-19 and 2019-20

Treatments combinations	**Nitrogen content (%)in grain**			**N content (%) in stover**			**Protein content (%)**		
	2018-19	**2019-20**	**Pooled Mean**	**2018-19**	**2019-20**	**Pooled Mean**	**2018-19**	**2019-20**	**Pooled Mean**
T_1 Control	1.71	1.70	1.70	0.05	0.04	0.045	10.80	10.82	10.81
T_2 50% NPK	1.76	1.77	1.76	0.07	0.08	0.075	11.05	11.07	11.06
T_3 100 NPK	1.79	1.80	1.79	0.08	0.09	0.085	11.20	11.22	11.21
T_4 50% NPK+S	1.73	1.74	1.73	0.07	0.08	0.070	11.12	11.15	11.13
T_5 100% NPK +S	1.82	1.83	1.82	0.08	0.09	0.085	11.35	11.37	11.36
T_6 50% NPK + Zn	1.77	1.78	1.77	0.07	0.07	0.070	11.09	11.11	11.10
T_7 100% NPK + Zn	1.75	1.76	1.75	0.07	0.08	0.075	11.31	11.33	11.32
T_8 50% NPK + S + Zn	1.74	1.75	1.74	0.08	0.09	0.085	11.15	11.18	11.16
T_9 100% NPK + S + Zn	1.83	1.84	1.83	0.09	0.10	0.095	11.45	11.48	11.46
SE (d)	0.027	0.029	0.020	0.009	0.014	0.008	0.057	0.068	0.014
CD (0.05%)	0.05	0.06	0.04	0.01	0.03	0.016	0.127	0.144	0.027

Summery and Conculation

- The similar pattern was also observed with respective to N content in stover of maize during first and second years, respectively. The highest N content was in T_9 whilst lowest in T_1 (control) during course of investigation. The maximum protein content was noted with the application of T_9 (100% RDF+S+Zn) respectively. The data clearly indicated that addition of Sulphur and Zinc significantly enhanced the protein content during first and second year respectively. The control gave the lowest value of protein during first and second year of experimentation.

- Different treatments in maize had significant influence on N content in both grain and straw of wheat during both the years. The maximum content was noted with the application of T_9 (100% RDF+S+Zn) but remained at par with T_5 (100% RDF+S) and T_7 (100% RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis. The graded application of RDF from 50 to 100% has further increased the concentration of protein. The maximum protein value content was noted with the application of T_9 (100% RDF+S+Zn). The data clearly indicated that addition of Sulphur and Zinc enhances the protein content significantly the first and second year respectively. But remained at par with T_5 (100% RDF+S) and T_7 (100% RDF+Zn) and significantly superior over rest of the treatments on pooled mean basis during course of investigation.
- **Recommendation** the over all assessment of results of present experiments it may be concluded that the both crop under cropping system can be grown with the T_9 100% NPK + S + Zn with different inorganic treatments were foundremunerative for the farmers of the central plain zone of Uttar Pradesh

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