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Response of sulphur, zinc and biofertilizer on content and uptake of N, P, K, S, Zn in rice-mustard cropping system

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Abstract
An investigation entitled " Response of Sulphur, Zinc and biofertilizer on content, uptake and available of N, P, K, S, Zn and microbial population in Rice Mustard Cropping System was carried out at Student's Instructional Farm C.S. Azad University of Agriculture and Technology, Kanpur during 2017-18 and 2018-19. There were 11 treatments *viz*. T_1 = control, T_2 = 100% RDF, T_3 = 100% RDF+20kg S, T_4 =100% RDF+40kg S, T_5 =100% RDF+5kg Zn, T_6 =100% RDF+10 kg Zn, T_7 =100% RDF+20kg S+5 kg Zn, T_8 =100% RDF+40 kg S+10 kg Zn, T_9 =100% RDF+ Biofertilizer, T_{10} =100% RDF+20kg S+5 kg Zn+ Biofertilizer and T_{11} =100% RDF+40 kg S+10 kg Zn+ Biofertilizer applied in hybrid rice cv. PHB-71 to observe their effect on rice and their residual effect on succeeding crop mustard in cv. Rohini with fertilized uniformly 100% RDF in randomized block design with three replication. The soil of the experimental field was slightly alkaline in nature having pH (8.14), EC (0.46) dSm^{-1}, OC (0.40%), available N (195.92 kg ha^{-1}). In hybrid rice combination of sulphur, zinc and biofertilizer with 100% RDF improved content and nutrient uptake over 100% RDF alone. The residual effect of combined source applied in hybrid rice was found significant on succeeding mustard crop. Basis on pooled data of the both year highest nutrient content maximum content percent (1.46, 0.28, 0.25, 0.11and 35.16 & 0.5, 0.08,1.22, 0.88 and 21.37) of N, P, K, S and Zn in grain and straw of rice and maximum uptake (104.04 kg ha^{-1}, 19.84 kg ha^{-1}, 17.84 kg ha^{-1}, 8.05 kg ha^{-1} and 2513.99 g/ha & 57.12 kg ha^{-1}, 8.75 kg ha^{-1}, 137.97 kg ha^{-1}, 99.40 kg ha^{-1} and 2416.12g/ha) of N, P, K, S and Zn in grain and straw of rice was recorded with the application of T_{11} (100% RDF+40 kg S+10 kg Zn+ Biofertilizer).
Same result of maximum content percent (3.47, 0.06, 0.67, 1.15 and 39.62 & 072, 0.20, 1.49, 0.16 and 26.02) in grain and straw and maximum uptake (73.95 kg ha^{-1}, 1.32 kg ha^{-1}, 14.24 kg ha^{-1}, 24.40 kg ha^{-1} and 844.22 g ha^{-1} & 40.53 kg ha^{-1}, 11.51 kg ha^{-1}, 83.59 kg ha^{-1}, 8.75 kg ha^{-1} and 1464.69 g ha^{-1}) of nutrients was also observed in mustard with similar treatment T_{11} (100% RDF).
On the basis of the result of the present investigation it can be concluded that combination of 100% RDF+40 kg S+10 kg Zn+ Biofertilizer in hybrid rice with 100% RDF in mustard is utmost essential to get highest nutrient content and uptake hybrid rice-mustard cropping system of the farmers of central plain zone of Uttar Pradesh.

Keywords: Response, zinc, biofertilizer, uptake, rice-mustard

Introduction
Rice-based cropping systems are most common in the middle Indo-Gangetic plains of the Indian subcontinent. It covers states of Uttar Pradesh, Bihar and West Bengal. These states produce maximum rice in India. The major crops grown in this area are rice (*Oryza sativa* L.) wheat, mustard, pulses, maize, sugarcane and other legumes. India is a major paddy producing country which produce nearly 21 per cent of the total rice production in world. (Ministry of Statistics and Program Implementation, 2012). Rice- mustard and rice-potato-fallow are two cropping systems that are extensively practiced by farmers of this region: such systems require very high inputs in terms of agricultural machinery, pesticides, fertilizers and other agro chemicals (Singh and Chancellor, 1975).
Rice is the rich source of energy and contains considerable amount of carbohydrate (70-80%), protein (6-10%), minerals (1.2-2.0%) and vitamin (Riboflavin, Thiamine, Niacin and Tocopheral). Rice provides 21% of global human per capita energy and 15% of per capita protein.
Mustard is one of the most important oilseed crop of India which belongs to genus *Brassica* of family Cruciferae. Rapeseed or mustard oil is the most important edible oil in north India which is difficult to be replaced by any other crop. India is the second largest producer of rapeseed-mustard after China.

Sulphur is considered one of the most important nutrient in soil. Best known is the role of sulphur and its benefits for skin, including appearance (skin structure), acne, wound healing, and overall skin health. Sulphur provides structure and elasticity at a molecular level. Di-sulfide bonds link skin proteins, like collagen and elastin, and are critical for skin's strong, yet flexible characteristic. These bonds can be stretched, yet retain shape once released. Additionally, as an integral part of the antioxidant and detoxification processes, sulphur is necessary to protect and maintain proper skin growth. Similarly, sulphur supports connective tissue. Tendons and ligaments rely on sulphur for proper cross-linking (di-sulfide bonds) in addition to extracellular matrix proteins like Glycosaminoglycan's and Hyaluronic Acids, which are highly sulfonated, and provide strength and cushion. In the liver, sulphur plays two critical roles. As a significant component of glutathione, the most prevalent antioxidant in the body, sulphur helps the body react to oxidative stress and maintain homeostasis, which is particularly relevant to exercise and aging. And as part of phase 2 detoxification, sulphur is essential to the metabolism and excretion of harmful substances.

Zinc is one of the most important micronutrient essential for plant growth especially for rice grown under submerged condition. Apart from major nutrients, it is very much responsive to high intensive cereal based cropping system. However, Zinc deficiency continues to be one of the key factors in determining rice production in several parts of the country (Kumararaja & Chandrasekharan, 2012). It is the most widespread micronutrient disorder in low land rice. In general zinc deficient show signs of low levels of auxins such as indole acetic acid (IAA). Though balanced and proportionate application of Zn along with NPK fertilizer increases the grain yield dramatically in most cases (Fageria *et al*., 2011) [25]. Zinc is required in a large number of enzymes and plays an essential role in DNA transcription. To give impetus to the vegetative growth zinc plays a vital role especially under low temperature ambient and rhizosphere regime. Furtgermore, zinc is especially important during periods of rapid growth, both pre- and postnatally, and for tissues with rapid cellular differentiation and turnover, such as the immune system and the gastrointestinal tract. Critical functions that are affected by zinc nutriture include pregnancy outcome, physical growth, susceptibility to infection, and neurobehavioral development, among others.

Biofertilizers spontaneously activates the microorganisms found in the soil in an effective and eco-friendly way, thereby gaining more importance for utilization in crop production, restoring the soils fertility and protecting it against drought, soil diseases and thus stimulate plant growth. Biofertilizers lead to soil enrichment and are suitable with long-term sustainability. Further, they pose no danger to the environment and can be substituted with chemical fertilizers. The application of bio-fertilizers can minimize the use of chemical fertilizers, decreasing environmental hazards, enhance soil structure and promote agriculture. Biofertilizers are cheaper and remarkable in affecting the yield of cereal crops.

Material and Methods

The present study entitled "Response of Sulphur, Zinc and biofertilizer on uptake, content and available of N, P, K, S, Zn and microbial population in Rice Mustard cropping system" was conducted during *Kharif* and *Rabi* season of 2017-18 and 2018-2019 respectively at Student Instructional Farm, Department of Agronomy, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur. The soil of the experimental field was alluvial in origin. Soil sample (0-15cm) depths were initially drawn from randomly selected parts of the field before sowing. The quantity of soil sample was reduced to about 500 gm through quartering technique. The soil sample was then subjected to mechanical and chemical analysis in order to determine the textural class and fertility status the soils were sampled to a depth of 0-30 cm of the soil, airdried and sieved (2 mm) for soil analyses. Some physical and chemical properties of soils are given in Table 1. Rice variety PHB -71 and mustard variety Rohini were used for experiment. In this experiment 11 treatments

T1 = control, T2 = 100%RDF, T3 = 100% RDF+20kg S, T4 =100% RDF+40kg S, T5 =100% RDF+5kg Zn, T6 =100% RDF+10 kg Zn, T7 =100% RDF+20kg S+5 kg Zn, T8 =100% RDF+40 kg S+10 kg Zn, T9 =100% RDF+ Biofertilizer, T10 =100% RDF+20kg S+5 kg Zn+ Biofertilizer and T11 =100% RDF+40 kg S+10 kg Zn+ Biofertilizer and 100% RDF in mustard were laid out in randomized block design with three replication having plot size 4 X 3 meter. Dose of fertilizers were applied are applied @ 150 kg N, 75 kg P_2 O_5, 60 K_2O_5, 25 kg S/ha, 5kg Zn/ha and 1liter/ha through Urea, DAP, MOP, Elemental sulphur, Zinc sulphate and PSB. Row to row and plant to plant distance in rice was kept 20 x15cm and in mustard 45 X 20cm respectively. Interculture operations: Weeding and hoeing were done with the help of Khurpi. Irrigation: Tube well was the source of the irrigation. Irrigation was done in when required in both crops. The crop was harvested at proper maturity stage determined by the visual operation.

Observation Recorded

The observations were recorded as per the procedure described below.

Soil Analysis

Mechanical separates: Soil separates analyzed by International pipette method as described by the Piper (1966).

pH: pH of the soil determined by using soil water suspension (1:2.5) with the help of digital pH meter.

EC: EC also determined using soil water suspension (1:2.5) with help of conductivity meter (Jackson, 1967).

Organic carbon: Organic Carbon was determined by Walkley and Black's rapid titration method as described by Jackson (1967). The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were subjected to statistical analysis using the methods advocated by Chandel (1990).

Plant analysis

The plant, grain and straw samples were processed for chemical analysis. The plant and straw samples were first dried in air, then in oven at 70^0C for 8 hours, ground in a Wiley mill having all stainless parts and then stored in polythene bags. Similarly, dried samples were also crushed and grinded.

1. **Nitrogen:** Nitrogen was determined by Kjeldal's method as described by Jackson (1967).

Preparation of extract: Oven dried and finally ground sampled of plant, grain and straw were weighed and digested in triacids mixture of concentrated sulphuric nitric and perchloric (10:4:1) and in their extracts phosphorous, potassium and zinc were determined. For determination of sulphur, the samples were digested in diacids mixtures of concentrated nitric and perchloric acids (9:1).

2. **Phosphorus:** Phosphorus was determined calorimetrically (Chapman and Pratt, 1961) in a diacid extract according to Jackson (1967).
3. **Potassium:** Potassium was determined by flame photometric method (Chapman and Pratt, 1961) in sodium acetate and acetic acid buffer as outlined by Jackson (1967).
4. **Sulphur:** In the extracts sulphur was determined by turbidimetric method of Chesnin and Yein (1950).
5. **Zinc:** Zinc concentration in the same digest of plant samples was estimated with the help of Atomic Absorption Spectrophotometer as described by Lindasey and Norwell (1978).

Uptake
The formula expressed below was used for the computation of uptake of the nitrogen, phosphorus, potassium, sulphur and zinc at harvest in both grains as well as straw.

$$\textbf{Uptake of nutrient (kg ha}^{-1}\textbf{)} = \frac{\text{Nutrient content (\%) X Yield (kg ha}^{-1}\text{)}}{100}$$

Statistical analysis
The data on various characters studied during the course of investigation were statistically analyzed for randomized block design. Wherever treatment differences were significant ("F" test), critical differences were worked out at five per cent probability level. The data obtained during the study were subjected to statistical analysis using the methods advocated by Chandel (1990).

Result and Discussion
Nitrogen Content
As data presented in table (2) shows that nitrogen content in grain and straw in rice varied from 1.110% to 1.45% in grain and 0.33% to 0.505% in straw. Maximum N content in both grain and straw was recorded in $T_{11.}$ (100% RDF+40 kg S+10 kg Zn+ Biofertilizer) followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and $T_8$100% RDF+40 kg S+10 kg Zn. However minimum nitrogen content was observed in control. Similar The result of this study is in agreement with Geeta Devi *et al.* (2000) [3], Kumar *et al.* (2002) [4] and Shivay and Kumar (2007) [5].

Phosphorus content
As data presented in table (3) shows that phosphorus content in grain and straw in rice varied from 0.14% to 0.28% in grain and 0.05% to 0.0.8% in straw. Maximum P content in both grain and straw was recorded in $T_{11.}$ (100% RDF+40 kg S+10 kg Zn+ Biofertilizer) followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and $T_8$100% RDF+40 kg S+10 kg Zn. However minimum phosphorus content was observed in control. The result of this study is in agreement with Sharma and Bapat (2000) [6], Kumar *et al.* (2002) [4] and Sudha and Chandini (2002) [7].

Potassium content
As data presented in table (4) shows that potassium content in grain and straw in rice varied from 0.09% to 0.25% in grain and 1.06% to 1.22% in straw. Maximum K content in both grain and straw was recorded in $T_{11.}$ (100% RDF+40 kg S+10 kg Zn+Biofertilizer) followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and $T_8$100% RDF+40 kg S+10 kg Zn. However minimum potassium content was observed in control. The result of this study is in agreement with Kumar *et al.* (2002) [4], Sudha and Chandini (2002) [7] and Wani and Refique (2000) [9].

Table 1: Soil properties of the top layer 0-30 cm of soil

S. No.	Particulars	Initial Values
A.	**Mechanical separate**	
1	Sand (%)	57.58
2	Silt (%)	22.19
3	Clay (%)	13.24
4	Textural class	Sandy loam
5	Bulk density (Mg m^{-3})	13.4
6	Particle density(Mg m^{-3})	2.69
B.	**Physico-chemical**	
1	pH (1:2.5)	8.17
2	EC (1:2.5) (dSm^{-1} at 25^0C)	0.46
3	CEC (Cmol (P^+) kg^{-1})	11.75

Table 2: Effect of sulphur zinc and biofertilizer on N, P, K, S and Zn content (%) in grain and straw of rice

Treatments of rice		N content (%)		P content (%)		K content (%)		S content (ppm)		Zn content(ppm)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	Control	1.110	0.333	0.139	0.046	0.086	1.058	0.078	0.510	22.850	15.945
T_2	100% RDF	1.155	0.385	0.214	0.069	0.220	1.078	0.100	0.777	31.080	18.875
T_3	100% RDF+20kg S	1.380	0.455	0.258	0.071	0.230	1.122	0.104	0.808	32.320	19.653
T_4	100% RDF+40kg S	1.395	0.465	0.264	0.075	0.239	1.172	0.108	0.840	33.600	20.430

T_5	100% RDF+5kg Zn	1.270	0.425	0.236	0.066	0.211	1.029	0.095	0.737	29.520	17.940
T_6	100% RDF+10 kg Zn	1.315	0.445	0.247	0.069	0.223	1.093	0.101	0.793	31.720	19.275
T_7	100% RDF+20kg S+5 kg Zn	1.415	0.475	0.258	0.072	0.234	1.143	0.106	0.824	32.965	20.020
T_8	100% RDF+40 kg S+10 kg Zn	1.425	0.485	0.269	0.076	0.242	1.186	0.110	0.855	34.200	20.785
T_9	100% RDF+Biofertilizer	1.240	0.415	0.231	0.064	0.204	1.083	0.101	0.778	31.120	18.915
T_{10}	100% RDF+20kg S+5 kg Zn+ Biofertilizer	1.435	0.495	0.275	0.076	0.247	1.205	0.112	0.865	34.840	21.165
T_{11}	100% RDF+40 kg S+10 kg Zn+Biofertilizer	1.455	0.505	0.280	0.078	0.249	1.220	0.113	0.879	35.160	21.365
S.Em ±		0.029	0.013	0.005	0.002	0.003	0.003	0.002	0.008	0.275	0.281
C.D. at 5%		0.082	0.037	0.015	0.005	0.008	0.010	0.004	0.022	0.786	0.801

Sulphur content

As data presented in table (2) shows that sulphur content in grain and straw in rice varied from 0.08ppm to 0.11ppm in grain and 0.51ppm to 0.88pp in straw. Maximum S content in both grain and straw was recorded in $T_{11.}$ (100% RDF+40 kg S+10 kg Zn+ Biofertilizer) followed by T_{10} (100% RDF+20kg S+5 kg Zn+Biofertilizer) and $T_8$100% RDF+40 kg S+10 kg Zn. However minimum sulphur content was observed in control. The result of this study is in agreement with Sudha and Chandini (2002) [7] and Ali *et al.* (2012). Rehman *et al.* (2008) [13] and Shivay and Kumar (2007) [5].

Zinc content

As data presented in table (2) shows that zinc content in grain and straw in rice varied from 22.85ppm to 35.16ppm in grain and 15.95ppm to 21.37ppm in straw. Maximum Zn content in both grain and straw was recorded in $T_{11.}$ (100% RDF+40 kg S+10 kg Zn+ Biofertilizer) followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and $T_8$100% RDF+40 kg S+10 kg Zn. However minimum zinc content was observed in control. The result of this study are in agreement with Upadhayay *et al.* (2011), Rehman *et al.* (2008) [13], Syeb *et al.* (2008), Singh *et al.* (2008) and Singh and Tripathi (2008) [16].

Mustard

Nitrogen Content

As data presented in table (2) shows that nitrogen content in grain and straw in rice varied from 3.10% to 3.47% in grain and 0.55% to 0.72% in straw. Maximum N content in both grain and straw was recorded in $T_{11.}$ (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). However minimum nitrogen content was observed in control. The result of this study is in agreement with Singh *et al.* (2010) [17], Singh *et al.* (2012), Chauhan *et al.* (2018), Sengar *et al.* (2000) and Dubey *et al.* (2016) [22].

Phosphorus content

As data presented in table (2) shows that phosphorus content in grain and straw in rice varied from 0.04% to 0.06% in grain and 0.16% to 0.20% in straw. Maximum phosphorus content in both grain and straw was recorded in $T_{11.}$ (100% RDF) followed by T_{10} (100% RDF) and $T_8$100% (RDF). However minimum phosphorus content was observed in control. The result of this study is in agreement Singh *et al.* (2012) and Chauhan *et al.* (2018), Sengar *et al.* (2000) and Dubey *et al.* (2016) [22].

Table 3: Effect of sulphur zinc and biofertilizer on N, P, K, S and Zn content percent in grain and straw of mustard

Treatments of mustard		N content (%)		P content (%)		K content (%)		S content (ppm)		Zn content(ppm)	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	Control	3.095	0.545	0.044	0.161	0.502	1.145	0.845	0.120	29.97	18.03
T_2	100% RDF	3.225	0.620	0.047	0.180	0.562	1.285	0.955	0.136	33.93	22.20
T_3	100% RDF	3.260	0.640	0.049	0.187	0.585	1.345	0.995	0.141	34.05	22.28
T_4	100% RDF	3.415	0.745	0.051	0.189	0.609	1.370	1.030	0.144	37.71	24.67
T_5	100% RDF	3.165	0.590	0.046	0.165	0.550	1.180	0.940	0.124	31.80	20.80
T_6	100% RDF	3.225	0.620	0.047	0.182	0.562	1.320	0.965	0.139	32.11	21.01
T_7	100% RDF	3.330	0.675	0.052	0.187	0.620	1.360	1.065	0.144	34.15	22.35
T_8	100% RDF	3.425	0.690	0.054	0.189	0.644	1.380	1.090	0.145	36.81	24.11
T_9	100% RDF	3.130	0.580	0.046	0.164	0.562	1.180	0.965	0.124	31.77	20.79
T_{10}	100% RDF	3.440	0.705	0.057	0.191	0.664	1.420	1.125	0.146	39.21	25.66
T_{11}	100% RDF	3.470	0.720	0.062	0.204	0.668	1.485	1.145	0.155	39.73	26.02
S.Em ±		0.027	0.014	0.001	0.002	0.005	0.031	0.019	0.003	0.87	0.74
C.D. at 5%		0.077	0.039	0.004	0.005	0.016	0.088	0.053	0.008	2.57	0.26

Potassium content

As data presented in table (2) shows that potassium content in grain and straw in rice varied from 0.50% to 0.67% in grain and 1.15% to1.49% in straw. Maximum potassium content in both grain and straw was recorded in $T_{11.}$ (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). However minimum potassium content was observed in control. The result of this study is in agreement with Singh *et al.* (2012) and Dubey *et al.* (2016) [22].

Sulphur content

As data presented in table (2) shows that sulphur content in grain and straw in rice varied from 0.85ppm to 1.15ppm in grain and 0.12ppm to 1.56pp in straw. Maximum S content in both grain and straw was recorded in $T_{11.}$ (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). However minimum sulphur content was observed in control. The result of this study is in agreement with Chandel *et al.* (2003) [21], Sriramachandrasekharan *et al.* (2004) [23], Rahman *et al.* (2009) and Singh *et al.* (2010) [17] and Dubey *et al.* (2016) [22].

Zinc content

As data presented in table (2) shows that zinc content in grain and straw in rice varied from 29.99ppm to 39.62ppm in grain and 18.03ppm to 26.02ppm in straw. Maximum zinc content in both grain and straw was recorded in $T_{11.}$ (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). However minimum zinc content was observed in control. The result of this study are in agreement Rahman *et al.* (2009), Gao, Xiaopeng *et al.* (2006) and Dubey *et al.* (2016) [22].

Rice crop

Nitrogen Uptake

There was a significant effect of the treatments on the nitrogen uptake in grain in straw. The highest 104.04 kg ha^{-1} N uptake by grain and straw 57.12 kg ha^{-1} was observed in T_{11} (100% RDF+40 kg S+10 kg Zn +Biofertilizer) and followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and T_8(100% RDF+40 kg S+10 kg Zn). The lowest nitrogen uptake in grain 33.87 kg ha^{-1} and straw 18.04 kg ha^{-1} was noted in control. A Similar result was noted by Chopra and Chopra (2000) [2], Geeta Devi *et al.* (2000) [3], Singh and Singh (2002) [8] and Shivay and Kumar (2007) [5].

Phosphorus uptake

There was a significant effect of the treatments on the phosphorus uptake in grain in straw. The highest 19.84 kg ha^{-1} phosphorus uptake by grain and straw 8.75 kg ha^{-1} was observed in T_{11} (100% RDF+40 kg S+10 kg Zn +Biofertilizer) and followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and T_8(100% RDF+40 kg S+10 kg Zn). The lowest P uptake in grain 4.44 kg ha^{-1} and straw 2.49 kg ha^{-1} was noted in control. The result of this study is in agreement with Sharma and Bapat (2000) [6], Kumar *et al.* (2002) [12] and Sudha and Chandini (2002) [7].

Potassium uptake

There was a significant effect of the treatments on the K uptake in grain in straw. The highest 17.84 kg ha^{-1} potassium uptake by grain and straw 137.97 kg ha^{-1} was observed in T_{11} (100% RDF+40 kg S+10 kg Zn +Biofertilizer) and followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and T_8(100% RDF+40 kg S+10 kg Zn). The lowest potassium uptake in grain 2.74 kg ha^{-1} and straw 57.88 kg ha^{-1} was noted in control. The result of this study is in agreement with Kumar *et al.* (2002) [12], Sudha and Chandini (2002) [7] and Wani and Refique (2000) [9].

Table 4: Effect of sulphur zinc and biofertilizer on N, P, K, S and Zn uptake (kg ha^{-1}) in grain and straw of rice

	Treatments of rice	N uptake kg/ha		P uptake kg/ha		K uptake kg/ha		S uptake kg/ha		Zn uptake g/ha	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	Control	33.87	18.04	4.44	2.49	2.74	57.88	2.50	27.90	731.745	872.225
T_2	100% RDF	60.61	32.73	11.10	5.82	11.57	91.62	5.25	66.03	1630.95	1604.12
T_3	100% RDF+20kg S	81.16	43.03	15.03	6.76	13.50	106.10	6.12	76.41	1900.46	1858.52
T_4	100% RDF+40kg S	88.05	47.37	16.24	7.43	14.87	116.86	6.73	83.81	2090.80	2037.14
T_5	100% RDF+5kg Zn	69.86	37.69	12.85	5.81	11.58	91.25	5.20	65.45	1623.64	1590.88
T_6	100% RDF+10 kg Zn	74.37	40.47	13.83	6.34	12.61	99.43	5.74	72.11	1793.81	1752.63
T_7	100% RDF+20kg S+5 kg Zn	92.11	48.99	16.87	7.59	15.42	120.35	6.97	86.80	2176.56	2108.85
T_8	100% RDF+40 kg S+10 kg Zn	97.09	52.57	18.16	8.18	16.49	128.55	7.49	92.67	2329.91	2252.83
T_9	100% RDF+Biofertilizer	67.34	36.31	12.38	6.06	11.11	94.29	5.46	68.06	1689.85	1654.63
T_{10}	100% RDF+20kg S+5 kg Zn+ Biofertilizer	100.82	55.24	19.11	8.54	17.32	134.51	7.83	96.57	2447.55	2361.61
T_{11}	100% RDF+40 kg S+10 kg Zn+Biofertilizer	104.04	57.12	19.84	8.75	17.84	137.97	8.05	99.40	2513.99	2416.12
	S.Em ±	1.30	0.97	0.37	0.26	0.33	1.90	0.16	1.34	27.11	30.57
	C.D. at 5%	3.71	2.78	1.05	0.74	0.95	5.42	0.47	3.83	77.38	87.25

Sulphur uptake

There was a significant effect of the treatments on the sulphur uptake in grain in straw. The highest 8.05 kg ha^{-1} sulphur uptake by grain and straw 99.40 kg ha^{-1} was observed in T_{11} (100% RDF+40 kg S+10 kg Zn +Biofertilizer) and followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and T_8(100% RDF+40 kg S+10 kg Zn). The lowest sulphur uptake in grain 2.50 kg ha^{-1} and straw 27.90 kg ha^{-1} was noted in control. The result of this study is in agreement with Sudha and Chandini (2002) [7] and Ali *et al.* (2012). Rehman *et al.* (2008) [13] and Shivay and Kumar (2007) [5].

Zinc uptake

There was a significant effect of the treatments on the zinc uptake in grain in straw. The highest 2513.99 g ha^{-1} Zn uptake by grain and straw 2416.12 g ha^{-1} was observed in T_{11} (100% RDF+40 kg S+10 kg Zn +Biofertilizer) and followed by T_{10} (100% RDF+20kg S+5 kg Zn+ Biofertilizer) and T_8 (100% RDF+40 kg S+10 kg Zn). The lowest Zn uptake in grain 731.74 g ha^{-1} and straw 872.23 g ha^{-1} was noted in control. The result of this study is in agreement with Rehman *et al.* (2008) [13], Syeb *et al.* (2018), Singh *et al.* (2008) and Singh and Tripathi (2008) [16].

Mustard

Nitrogen uptake

There was a significant effect of the treatments on the nitrogen uptake in grain in straw. The highest 73.95 kg ha^{-1} N uptake by grain and straw 40.53 kg ha^{-1} was observed in T_{11} (100% RDF) and followed by T_{10} (100% RDF) and T_8 (100% RDF). The lowest nitrogen uptake in grain 27.62 kg ha^{-1} and straw 13.90 kg ha^{-1} was noted in control. Similar result was noted by Ahmed *et al.* (1988) [1], Chopra and Chopra (2000) [2], Geeta Devi *et al.* (2000) [3], Singh and Singh (2002) [8], Kumar *et al.* (2002) [4] and Shivay and Kumar (2007) [24].

Phosphorus uptake

There was a significant effect of the treatments on the phosphorus uptake in grain in straw. The highest 1.32 kg ha^{-1} phosphorus uptake by grain and straw 11.51 kg ha^{-1} was observed in T_{11} (100% RDF) and followed by T_{10} (100% RDF) and T_8 100% RDF). The lowest P uptake in grain 0.39 kg ha^{-1} and straw 4.12 kg ha^{-1} was noted in control. The result of this study is in agreement with Sharma and Bapat (2000) [6], Kumar *et al.* (2002) [12] and Sudha and Chandini (2002) [7].

Potassium uptake

There was a significant effect of the treatments on the K uptake in grain in straw. The highest 14.24 kg ha^{-1} potassium uptake by grain and straw 83.59 kg ha^{-1} was observed in T_{11} (100% RDF) and followed by T_{10} (100% RDF) and T_8 (100% RDF). The lowest potassium uptake in grain 4.48 kg ha^{-1} and straw 29.19 kg ha^{-1} was noted in control. The result of this study is in agreement with Sudha and Chandini (2002) [7] and Wani and Refique (2000) [9].

Table 5: Effect of sulphur zinc and biofertilizer on N, P, K, S and Zn uptake (kg ha^{-1}) in grain and straw in Mustard

Treatments of mustard		N uptake kg/ha		P uptake kg/ha		K uptake kg/ha		S uptake kg/ha		Zn uptake g/ha	
		Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1	Control	27.62	13.90	0.39	4.12	4.48	29.19	7.54	3.07	267.67	459.48
T_2	100% RDF	50.18	26.45	0.74	7.70	8.74	54.85	14.86	5.82	527.63	947.37
T_3	100% RDF	53.73	28.69	0.81	8.38	9.64	60.30	16.40	6.34	560.57	998.48
T_4	100% RDF	64.34	37.87	0.96	9.63	11.47	54.83	19.41	7.34	709.90	1257.32
T_5	100% RDF	48.68	24.70	0.71	6.91	8.47	49.41	14.46	5.19	488.71	870.89
T_6	100% RDF	51.78	27.20	0.75	7.98	9.02	57.90	15.49	6.10	515.05	921.50
T_7	100% RDF	58.20	32.01	0.89	8.86	10.84	64.46	18.62	6.80	596.43	1058.95
T_8	100% RDF	67.61	36.56	1.07	10.01	12.70	73.12	21.52	7.68	726.04	1277.10
T_9	100% RDF	46.75	24.11	0.70	6.82	8.39	49.04	14.41	5.15	473.97	864.04
T_{10}	100% RDF	69.85	38.12	1.16	10.33	13.48	76.79	22.84	7.92	795.56	1387.45
T_{11}	100% RDF	73.95	40.53	1.32	11.51	14.24	83.59	24.40	8.75	844.22	1464.69
S.Em ±		0.93	0.79	0.05	0.31	0.27	1.26	0.54	0.16	13.64	27.15
C.D. at 5%		2.64	2.25	0.16	0.87	0.77	3.60	1.54	0.45	38.94	77.50

Sulphur uptake

There was a significant effect of the treatments on the sulphur uptake in grain in straw. The highest 24.40 kg ha^{-1} sulphur uptake by grain and straw 8.75 kg ha^{-1} was observed in T_{11} (100% RDF) and followed by T_{10} (100% RDF) and T_8 (100% RDF). The lowest sulphur uptake in grain 7.54 kg ha^{-1} and straw 3.07 kg ha^{-1} was noted in control. The result of this study is in agreement with Sakal *et al.* (1999) [10], Sudha and Chandini (2002) [7] and Ali *et al.* (2012). Rehman *et al.* (2008) [13] and Shivay and Kumar (2007) [24].

Zinc uptake

There was a significant effect of the treatments on the zinc uptake in grain in straw. The highest 844.22 g ha^{-1} Zn uptake by grain and straw 1464.69 g ha^{-1} was observed in T_{11} (100% RDF) and followed by T_{10} (100% RDF) and T_8 (100% RDF). The lowest Zn uptake in grain 267.74 g ha^{-1} and straw 459.48 g ha^{-1} was noted in control. The result of this study is in agreement with Rehman *et al.* (2008) [13], Syeb *et al.* (2018), Singh *et al.* (2008) and Singh and Tripathi (2008) [16].

Conclusion

Study suggests that maximum content percent (1.46, 0.28, 0.25, 0.11and 35.16 & 0.5, 0.08,1.22, 0.88 and 21.37) of N, P, K, S and Zn in grain and straw of rice and maximum uptake (104.04 kg ha^{-1}, 19.84 kg ha^{-1}, 17.84 kg ha^{-1}, 8.05 kg ha^{-1} and 2513.99 g/ha & 57.12 kg ha^{-1}, 8.75 kg ha^{-1}, 137.97 kg ha^{-1}, 99.40 kg ha^{-1} and 2416.12g/ha) of N, P, K, S and Zn in grain and straw of rice was recorded with the application of T_{11} (100% RDF+40 kg S+10 kg Zn+ Biofertilizer).

Same result of maximum content percent (3.47, 0.06, 0.67, 1.15 and 39.62 & 072, 0.20, 1.49, 0.16 and 26.02) in grain and straw and maximum uptake (73.95 kg ha^{-1}, 1.32 kg ha^{-1}, 14.24 kg ha^{-1}, 24.40 kg ha^{-1} and 844.22 g ha^{-1} & 40.53 kg ha^{-1}, 11.51 kg ha^{-1}, 83.59 kg ha^{-1}, 8.75 kg ha^{-1} and 1464.69 g ha^{-1}) of nutrients was also observed in mustard with similar treatment T_{11} (100% RDF).

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