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To study the effect of soil test crop based nutrient application on growth, yield and partitioning of Sulphur in plant

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Abstract
An experiment was conducted on medium black soil at research field of Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur. To study the effect of soil test crop based nutrient application on growth, yield and partitioning of sulphur in plant. The experiment was laid out in RBD six treatment with four replication *viz*, T_1: control, T_2: GRD, T_3: T.Y. 50 q ha^{-1} T_4: T.Y. 60 q ha^{-1}, T_5: T.Y. 50 q^{-1} + 5 t ha^{-1} FYM, T_6: T.Y. 60 q ha^{-1} + 5 t ha^{-1} FYM. The result revealed that rice growth, yield was significantly higher in treatment T6 (5781) kg ha^{-1} which was find significantly superior to T.Y. 50 q ha^{-1} (38-65-60) and GRD (120-60-40). The application of N P K for T4 and T6 significantly increased in shoot and root of rice plant at 60 and 90 DAS and in grain and straw.

Keywords: STCR, partitioning, rice

Introduction
Rice (Oryza sativa) is staple food of millions of people and provides about 700 calories/day/person for about 3000 million people living mostly in developing countries (Singh *et al*. 2017). The rice grain consists of 75-80% starch, 12% water and only 7% protein with full complement of amino acids and higher concentration of lysine, minerals like calcium, magnesium, phosphorous are present along with some traces of iron, copper, zinc, manganese.
The slogan 'Rice is life' is most appropriate for India; as this crop plays a vital role in our India's food security and is a mean of livelihood for millions of rural households (Ajay kumar *et al*. 2016) [1]. Imbalanced fertilizers of major nutrients is one of the reason for lower production of Rice in India (Reddy and Ahmed 2000) [16].
In India Rice production is 105.42 MT from 43.70 M ha land with the productivity of 24.12 q ha^{-1} and in Madhya Pradesh, rice production is 4.23 MT from 2.29 M ha land with the productivity of 18.47 q ha^{-1} (Anonymous, 2018).
Soil testing as a tool for judicious fertilizer use is well recognized practice all over the world which take care of too little, too much or disproportionate application of nutrients. The use of both organic and inorganic fertilizers by farmers has been reported to increase yield and sustain soil productivity (Chukwu *et al*. 2012) [6]. Fertilizer is one of the costliest inputs in agriculture and the use of the right amount of fertilizer is fundamental for farm profitability and environmental protection (Kimetu *et al*. 2004) [14].
Sulphur is involved in amino acid and protein synthesis, enzymatic and metabolic activities in plants, which account for approximately 90% of organic sulphur in plant. Its deficiency is fast emerging in areas under oilseeds and pulses due to higher removal of S by crops (Singh and Kumar, 2009). Sulphur is an essential macronutrient for plants ranked 4th after nitrogen, phosphorous, potassium because of its indispensable role in proteins synthesis, vitamins, enzymes and flavoured compounds in plant (Bera and Ghosh, 2015; Islam *et al*. 2016) [3, 10].

Material and Methods
The study was conducted in Kharif season of 2019 at the JNKVV research field, Department of Soil Science and Agricultural Chemistry, AICRP on STCR, Jabalpur (M.P.), situated in the South-Eastern part of Madhya Pradesh at 23° 13′ North latitude, 79° 57′ East longitudes and at an elevation of 393 meter above mean sea level. The expeiment was laid out in randomized block design (RBD) six treatment with four replication *viz*; Control, General Recommended Dose (GRD), Targeted yield of 50 q ha^{-1}, Targeted Yield of 60 q ha^{-1}, Targeted Yield of 50 q + 5 t FYM ha^{-1} and Targeted Yield of 60 q + 5 t FYM ha^{-1}, respectively.

The soil of the experimental site belongs to Vertisol, Kheri series of fine montmorillonitic hyperthermic family of Typic Haplusterts popularly known as medium deep black soil. The physico-chemical properties of experimental soil were presented in table 1.

Five plants per plot were selected at random in net plot area and tagged for recording observations. The morphological characters of rice such as plant height, number of tillers plant^{-1} and dry matter accumulation of shoot-roots plant^{-1}were taken periodically at 60, 90 days after sowing (DAS) and at harvest. Post-harvest observations yield attributes *viz*; Panicle length, Panicle weight plant^{-1}, Number of grains panicle^{-1}, Weight of grains panicle^{-1}, Test weight of grains, Harvest Index.

Statistical analysis

The data pertaining to each character of the rice crop were tabulated and analyzed statistically by applying the standard technique. Analysis of variance (ANOVA) for randomized block design was worked out and the significance of treatments were tested to draw valid conclusions as described by Gomez and Gomez (1984). The differences of treatments mean were tested by 'F' test of significance on the basis of null hypothesis. Critical differences were worked out at 5 percent level of probability where 'F' test was significant. If the variance ratios (F-test) were found significant at 5% level of significance, the standard error of mean (SE m) and critical differences (CD) were calculated accordingly.

Result and Discussion

The experiment was conducted on medium black soil at Research field of Department of Soil Science and Agricultural Chemistry, JNKVV, Jabalpur following all standard agronomic management practices except those under treatments. Six treatments of soil test based integrated nutrient application, for different targeted yield, were laid out in randomized block design with four replications. The treatments consisted of T_1: control; T_2: GRD (120-60-40 kg N, P_2O_5 and K_2O ha^{-1}); T_3: 138-65-60 kg N, $P_2O_5$and K_2O ha^{-1} (T.Y. 50 q ha^{-1}); T_4: 178-86-79 kg N, P_2O_5 and K_2O ha^{-1} (T.Y. 60 q ha^{-1}); T_5: 134-50-57 kg N, P_2O_5 and K_2O ha^{-1} (T.Y. 50 q + FYM 5 t ha^{-1}) and T_6: 174-71-76 kg N, P_2O_5 and K_2O ha^{-1} (T.Y. 60 q + FYM 5 t ha^{-1}).

Keeping in view the objectives of the investigation, observations and the results were recorded, processed statistically on various parameters for scientific interpretation of the results. In light of the objectives results are summarized as below:

The application of NPK @ GRD (120-60-40), T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79) and T.Y.60q+5 t FYM (174-71-76) successively and significantly increased the plant height of rice at 60, 90 DAS and at harvest except T.Y. 60 q (178- 86-79) at 90 DAS and at harvest. The maximum plant height of rice was observed at 60 DAS 59.33 cm, 90 DAS 77.98 and at harvest 78.13 cm with the application of NPK for T.Y.60q+5 t FYM (174-71-76). The findings are in accordance with the results reported by Ghosh *et al*., (2015) [7] and Mahmud *et al*. (2016) [14]. The application of nutrients for T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) significantly increased the number of tillers over GRD at 60 DAS. Similar findings have been also reported by Srivastava (2013) [21] and Mahmud *et al*. (2016) [14].

The application of nutrients for @ general recommended dose (GRD) of NPK (120-60-40), T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) significantly increased the dry matter accumulation at all the growth stages of rice over control. The maximum dry matter accumulation at 60 DAS (9.76 g), 90 DAS (19.12 g) and at harvest (18.45 g) were observed with the application of nutrients for T.Y.60q+5 t FYM (174-71-76) which was found significantly superior to all the treatments at all growth stages. Similar result on dry matter production was recorded by Srivastava (2013) [21], Vidya *et al*. (2015) [23] and Ghosh *et al*. (2015) [7].

The application of NPK nutrients for T.Y.50 q (138-65-60), T.Y.60 q (178-86-79), T.Y. 50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) significantly increased the panicle length, number of grains panicle^{-1}, grain weight panicle^{-1} and test weight of rice over control. Increase of number of grain panicle-1 with increased NPK application was also reported by Naing Oo *et al*. (2010), and Mahmud *et al*. (2016) [14]. Increase of test weight with increased NPK was reported by Srivastava (2013) [21].

The application of nutrients @ general recommended dose (GRD) of NPK (120-60-40), T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) significantly increased the grain and straw yield of rice over control. The maximum grain (5781 kg ha^{-1}) and straw (7598 kg ha^{-1}) yield was observed with T.Y.60q+5 t FYM (174-71-76) which was found significantly superior to T.Y.50 q (138-65- 60) and GRD (120-60-40). The findings are in good agreement of those reported by Naing Oo *et al*. (2010), Mahmud *et al*. (2016) [14]. The NPK nutrients @ T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) significantly increased N content in rice plant at 60 DAS and 90 DAS over control except nutrients application for T.Y.50 q ha^{-1}at While the application of GRD, T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) resulted significantly higher N content in grain and straw of rice over control. The maximum N content at 60 DAS 1.94%, 90 DAS 1.83%, grain 1.18% and straw 0.59% were observed with the NPK application for T.Y.60q (5 t FYM + 174-71-76). The findings are in good agreements and well supported by Kafle and Sharma (2015) [12].

The application of nutrients @ general recommended dose (GRD) of NPK (120-60-40), T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), and T.Y.60q+5 t FYM (174-71-76) successively and significantly increased the phosphorous content in rice at 60 and 90 DAS and in grain and straw of rice. While the application of NPK for T.Y.50q (5 t FYM + 134-50-57) was found significantly superior to nutrient application for T.Y.50 q (138-65-60) at 60 DAS and in straw. The maximum P content at 60 DAS 0.18%, 90 DAS 0.175%, grain 0.111% and straw 0.052% were observed with application of nutrients for T.Y.60q+5 t FYM (174-71-76). Similar results have been reported by Singh (2017) and Sivaranjani *et al*. (2018) [20].

The application of nutrients @ general recommended dose (GRD) of NPK (120-60-40), T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) significantly increased K content in rice plant at 60 DAS and 90 DAS and in straw over control except with GRD at 90 DAS. However, the application of nutrients for T.Y.60q+5 t FYM (174-71-76) resulted significantly higher K content at 60 and 90 DAS over GRD, T.Y.50 q (138-65-60) and T.Y.50q+5 t FYM (134-50-57). While, the application of nutrients for T.Y.60q+5 t FYM (174-71-76) also significantly increased the K content in grain and straw of rice over control and GRD respectively. The maximum K content at 60 DAS 2.86%, 90 DAS 2.65%, grain 0.64% and straw 1.73% were observed with NPK application for T.Y.60q+5 t FYM (174-71-76). The findings are in good agreement and well supported by Challa Venureddy *et al.* (2014) [4] and Sivaranjani *et al.* (2018) [20].

The application of NPK for T.Y.60 q (178-86-79) and T.Y.60 (174-71-76) + 5t FYM significantly increased S content in shoot and root of rice plant at 60 and 90 DAS and in grain and straw. Though the NPK application for T.Y.60 (174-71-76) + 5t FYM was found significantly superior to T.Y.50 (134- 50-57) + 5t FYM GRD and T.Y.50 q (138-65-60) for S content in shoot at 90 DAS. However the nutrient application for T.Y.60 (174-71-76) + 5t FYM was found significantly superior to GRD and T.Y.50 q (138-65-60) for S content in root and shoot at 60 and 90 DAS and in grain. The maximum S content in shoot (0.123%) and root (0.062%) at 60 and shoot (0.118%) and root (0.061%) 90 DAS and in grain (0.052%) and straw (0.050%) were recorded with nutrient application for T.Y.60 (174-71-76 + 5t FYM). These findings are supported by Jawahar and Vaiyapuri (2013), J. K. Malav and J. K. Patel (2017) reported that the application of different level of nitrogen and silicon significantly influenced the S uptake in grain and straw. The application of general recommended dose (GRD) of NPK (120- 60-40), T.Y.50 q (138-65-60), T.Y.50q+5 t FYM (134-50-57), T.Y. 60 q (178-86-79) and T.Y.60q+5 t FYM (174-71-76) significantly increased nutrient uptake of (N,P,K and S) by grain, straw and total uptake by rice. However, the application of NPK for T.Y.60q+5 t FYM (174-71-76) was found significantly superior to GRD (120-60-40), T.Y.50 q (138-65-60) for N uptake by grain, straw and total N uptake.

Though the N uptake by grain with T.Y.60q+5 t FYM (174-71-76) was found significant over T.Y.50q+5 t FYM (134-50-57). The application of nutrients for T.Y.60q+5 t FYM (174-71-76) was also found significant over GRD and T.Y.50 q (138-6560) for P,K and S uptake by grain, straw and total uptake by rice.

The application of NPK nutrients for T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) or T.Y.60q+5 t FYM (174-71-76) successively and significantly increased electrical conductivity of soil. However, the maximum E.C. 0.357 d S m^{-1} was observed with T.Y.60q+5 t FYM (174-71-76). Similar results were also reported by Habtamu (2015) [9] and Monsefi *et al.* (2016) [15].

The application of NPK nutrients for T.Y.50 q (138-65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) signifiicantly increased organic carbon of soil over control. However, the maximum O.C. 5.57 g $kg^{-1}$was observed with T.Y.60q+5 t FYM (174-71-76) which was found significantly superior to GRD. The findings are in good agreement to those reported by Kalhapure *et al.* (2013) [13], Habtamu (2015) [9].

The application of NPK nutrients @ GRD (120-60-40), T.Y.50 q (138- 65-60), T.Y. 60 q (178-86-79), T.Y.50q+5 t FYM (134-50-57) and T.Y.60q+5 t FYM (174-71-76) significantly increased available N, P and K in soil over control. However, the application of nutrient for T.Y.60q+5 t FYM (174-71-76) resulted maximum N (174 kg ha^{-1}), P (30.5 kg ha^{-1}) and K (267 kg ha^{-1}) which was found significantly superior to GRD (120-60-40), T.Y.50 q (138- 65-60), T.Y. 60 q (178-86-79) for available P. The nutrient application for T.Y.60q+5 t FYM (174-71-76) also found significantly superior to GRD for available K

Table 1: Physico-chemical properties of experimental soil

Particulars	Values	Method employed
Soil pH (pH 1:2.5 at 25 °C)	7.53	Glass electrode pH meter (Jakson, 1973)
Electrical Conductivity (dS m^{-1} at25 °C)	0.323	Electrical conductivity meter (Jakson, 1973)
Organic Carbon (g kg^{-1})	5.30	Potassium dichromate rapid titration method (Walkley and Black, 1934) [24]
Available Nitrogen (kg ha^{-1})	165.81	Alkaline potassium permanganate method (Subbiah and Asija, 1956) [22]
Available Phosphorous (kg ha^{-1})	23.20	Soil extracted with 0.5 M $NaHCO_3$ and colour development by ascorbic acid (Watanabe and Olsen´s, 1965) [25]
Available Potassium (kg ha^{-1})	251.13	Neutral normal ammonium acetate method by using Flame photometer (Jackson, 1973) [11]
-1Available Sulphur (kg ha^{-1})	19.72	Turbidimetric method (Chesnin and Yien, 1951) [5]

Table 2: Effect of fertility levels with and without FYM on plant height, number of tillers $plant^{-1}$ and dry matter accumulation in plant at different growth stages of rice-

Treatments	Plant height (cm)			Number of tillers plant-1			Dry matter accumulation in plant		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1: Control (0-0-0 kg N-P_2O_5-K_2O ha-1)	43.15	51.03	51.46	2.25	4.25	5.50	1.77	4.35	3.08
T_2: GRD (120-60-40 kg N-P_2O_5-K2O ha-1)	51.21	64.93	65.57	2.50	5.75	7.75	5.91	8.93	8.53
T_3: T.Y. 50 q ha-1 (138-65-60 kg N-P_2O_5-K_2O ha-1)	54.21	69.95	70.23	3.50	6.75	8.50	6.89	12.59	12.06
T_4: T.Y. 60 q ha-1 (178-86-79 kg N-P_2O_5-K_2O ha-1)	56.57	71.33	71.61	3.75	7.25	8.50	8.63	15.75	14.99
T_5: T.Y. 50 q + 5 t FYM ha-1 (134-50-57 kg N-P_2O_5-K_2O ha-1)	54.43	70.14	70.47	4.00	7.25	8.75	7.66	15.41	14.69
T_6: T.Y. 60 q + 5 t FYM ha-1 (174-71-76 kg N-P_2O_5-K_2O ha-1)	59.33	77.98	78.13	4.75	8.50	11.75	9.76	19.12	18.45
SE m ±	0.33	0.72	0.86	0.31	0.49	0.42	0.30	0.58	0.60
CD *(p=0.05)*	1.11	2.43	2.88	1.04	1.66	1.40	1.02	1.95	2.00

Table 3: Effect of fertility levels with and without FYM on sulphur partitioning in rice

Treatment	Sulphur content in rice (%)					
	60 DAS		90 DAS		At Harvest	
	Shoot	Root	Shoot	Root	Grain	Straw
T_1: Control (0-0-0 kg N- P_2O_5-K_2O ha-1)	0.109	0.056	0.108	0.055	0.048	0.042
T_2: GRD (120-60-40 kg N-P_2O_5-K_2O ha-1)	0.113	0.058	0.110	0.056	0.049	0.042
T_3: T.Y. 50 q ha-1 (138- 65-60kg N-P_2O_5-K_2O ha-1)	0.115	0.059	0.111	0.057	0.049	0.046
T_4: T.Y. 60 q ha-1 (178- 86-79kg N-P_2O_5-K_2Oha-1)	0.119	0.061	0.114	0.059	0.051	0.048
T_5: T.Y. 50 q + 5 t FYM ha-1 (134-50-57 kg N-P_2O_5-K_2O ha-1)	0.117	0.059	0.112	0.058	0.050	0.048
T_6: T.Y. 60 q + 5 t FYM ha-1 (174-71-76 kg N-P_2O_5-K_2O ha-1)	0.123	0.062	0.118	0.061	0.052	0.050
SE m ±	0.0025	0.0012	0.0018	0.0011	0.0007	0.0017
CD (p=0.05)	0.0084	0.0040	0.0060	0.0038	0.0025	0.0058

Table 4: Effect of fertility levels with and without FYM on available nutrients in soil

Treatments	Available primary nutrients (kg ha^{-1})			Grain yield (kg ha^{-1})
	Available N	Available P	Available K	
T_1: Control (0-0-0 kg N-P_2O_5- K2O ha-1)	126	11.5	196	2495
T_2: GRD (120-60-40 kg N- P_2O_5-K_2O ha-1)	148	21.9	227	4135
T_3: T.Y. 50 q ha-1 (138-65-60 kg N-P_2O_5-K_2O ha-1)	157	23.6	240	4768
T_4: T.Y. 60 q ha-1 (178-86-79 kg N-P_2O_5-K_2O ha-1)	165	26.8	252	5346
T_5: T.Y. 50 q + 5 t FYM ha-1 (134-50-57 kg N-P_2O_5-K_2O ha-1)	166	27.1	254	5239
T_6: T.Y. 60 q + 5 t FYM ha-1 (174-71-76 kg N-P_2O_5-K_2O ha-1)	176	30.5	267	5781
SE m ±	7.43	1.11	11.45	218
CD (p=0.05)	22.9	3.43	35.3	671

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