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Effect of sulphur, zinc and biofertilizer on growth and yield parameters in rice-mustard cropping

Rajesh Kumar and Sushil Dimree

Abstract
An investigation entitled "Response of sulphur, Zinc and Biofertilizer on uptake, crop quality and yield parameters of 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.

In hybrid rice combination of sulphur, zinc and biofertilizer with 100% RDF improved growth attributes and yield attributes over 100% RDF alone. The residual effect of combined source applied in hybrid rice was found significant on succeeding mustard crop. Growth parameters *viz* as plant height 30,60, 90 and at harvest (41.90 cm, 74.02 cm, 92.53 cm & 107.30 cm), number of hills per square meter (49.60), number of tillers per hill at 30 days (12.63), number of effective tillers per square meter 90 DAT (374.70), number of spikes per ear (12.70), length of ear (28.31cm), number of grains per ear (194.42), grain weight per ear (6.80 g), test weight 1000 grains (23.74), bundle weight per plot (22.15 kg), grain weight per plot (8.58), biological yield (184.59q/ha), grain yield (71.50 q/ha), straw yield (113.09 q/ha), harvest index (38.74%) and in case of mustard plant height 30,60, 90 and At harvest(14.48cm, 58.34cm, 112.48 cm & 128.88 cm), plant population per row (14.26), number of primary, secondary and tertiary branches (5.96, 13.71 & 13.90), number of pod per plant (367.89), number of grains per pod (13.53), test weight 1000 grains (4.38 g), grain weight per plot (3.56 kg), bundle weight per plot (9.32 kg) stover yield per plot (4.30 kg) biological yield (77.63 q/ha), grains yield (21.31 q/ha), stover yield (56.29 q/ha), harvest index (27.30%).

Highest grain yield of rice 71.50 q ha^{-1} which was 26.61% higher than 100% RDF and highest grain yield of mustard 21.31 q ha^{-1} which was 31. 31% higher than 100% RDF was recorded with the application T_{11} 100% RDF+40 kg S+10 kg Zn+ Biofertilizer. Application of T_{11} 100% RDF+40 kg S+10 kg Zn+ Biofertilizer +(100% RDF) was found economically superior over other treatments during both the years.

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 growth and yield hybrid rice-mustard cropping system of the farmers of central plain zone of Uttar Pradesh.

Keywords: Sulphur, zinc, biofertilizer, parameters, rice-mustard

Introduction
Rice-based cropping systems are most common to the middle Indo-Gangetic plains of the Indian subcontinent, which covers an area of 9.64 Mha (Gangwer *et al*., 2005) [5]. It covers the states of Uttar Pradesh, Bihar and West Bengal. These states produce maximum rice in India. The major crops grown in this area are rice, wheat, potato, mustard, pulses, maize and other legumes. India is a major paddy producing nation which accounts nearly 21 per cent of the total white rice production (Ministry of Statistics and Program Implementation, 2012). Paddy-wheat 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).

Oilseed plays vital role in economy, accounting for 5 per cent of the gross national product and 10 per cent of the value of agriculture products (F.A.O.2001); in India, rapeseed and mustard are considered next to groundnut as 'cash crop' in oilseed economy covering 4.5mha with a contribution of 4.2 mt in 2000-2001 in India.

Mustard is one of the most important oilseed crop of India that belongs to genus Brassica of family Cruciferae. The oilseeds Brassicas comprises of four species: *Brassica campestris*, *Brassica juncea*, *Brassica napus* (winter and spring rape) and *Brassica carinata*. 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. In India, it is mostly grown on area 5.76 m ha with production of 6.82 m tonnes and productivity an average of 1184 kg ha'. In Uttar Pradesh rapeseed is grown on 0.59 m ha with production of about 0.60 m tonnes with an average yield of 1015 kg ha^{-1} (Anonymous, 2015-16) [1]. Nitrogenous fertilizers applied to proceeding rice crop leaves significant residual effect for succeeding mustard to produce higher crop growth and yield (Vidya Sagar 1997), under this situation rice mustard to be one of the best alternative cropping system, which is much less labour and input expensive. To get optimum yield compromising with the availability of resources the water requirement may also be minimum.

Sulphur is an essential macronutrient for plants, ranked 4th after nitrogen, phosphorus and potassium because of its indispensable role in protein synthesis, vitamins, enzyme and flavoured compounds in plants (Bera and Ghosh, 2015) [13].

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. Biofertilizers are becoming increasingly popular in many countries and for many crops. They are defined as products containing active or latent strains of soil microorganisms, either bacteria alone or in combination with algae or fungi that increase the plant availability and uptake of mineral nutrients through nitrogen fixation from atmosphere and/or solubilizing of nutrients.

Material and Method

The present study entitled Effect of Sulphur, Zinc and biofertilizer on growth and yield parameters in Rice – Mustard cropping at Student Instructional Farm, Department of Agronomy Chandra Shekhar Azad University of Agriculture & Technology, Rice variety PHB -71 and mustard variety Rohini were used for experiment. In this experiment 11 treatments

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 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_2O_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. For this purpose, 5 plants were selected randomly in each net plot and were tagged with a level for recording various observations on growth and yield parameters. Biometric observation: Biometric observation in case of rice such as plant height 30,60, 90 and at harvest, number of hills per square meter, number of tillers per hill at 30 days, number of effective tillers per square meter, number of spikes per ear, length of ear (cm), number of grains per ear, grain weight per ear (g), test weight 1000 grains, bundle weight per plot (kg), grain weight per plot, biological yield q/ha, grain yield q/ha, straw yield q/ha, harvest index percent and in case of mustard plant height 30,60, 90 and At harvest, plant population per row, number of primary secondary and tertiary branches, number of pod per plant, number of grains per pod, grain weight per plot, test weight 1000 grains, bundle weight per plot (kg) stover yield per plot (kg) biological yield q/ha, grains yield q/ha, stover yield q/ha, harvest index per cent were recorded treatment wise grain and stalk yields were recorded per plot and converted into quintal ha-1

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

Growth attributes of rice

Plant height (cm) 30, 60, 90 DAS & at harvest:

As the data presented in the table (1) showed, there was a significant relationship among all the treatments. Highest plant height (cm) 30, 60, 90 DAS & at harvest (41.90 cm, 74.02 cm, 92.53 cm & 107.30 cm) 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+40kg S +10 Zn). The minimum plant height was recorded in control. A similar result was reported by Shekara *et al*. (2011) [23], Singh *et al* (2012), Mahmood *et al*. (2016) and Kumar *et al.* (2018).

Number of hills per square meter

As the data presented in the table (1) showed, there was a significant relationship among all the treatments. Highest number of hills per square meter 49.60 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+40kg S +10 Zn). The minimum number of hills per square meter was recorded in control. Ming- ming wang (2010) [9] and Kumar *et al.* (2018).

Number of tillers $hill^{-1}$ at 30 DAT

As the data presented in the table (1) showed, there was a significant relationship among all the treatments. Highest number of tillers $hill^{-1}$ at 30 DAT 12.63 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+40kg S +10 Zn). The minimum number of tillers $hill^{-1}$ was recorded in control. A similar result was recorded by

Tunga and Nayak (2000) [33], Wang *et al*. (2000), Krishna *et al*. (2008) [7] and Siddika *et al*. (2016) [26].

Number of effective tillers meter^{-2} 90 DAS

As the data presented in the table (1) showed, there was a significant relationship among all the treatments. Highest number of effective tillers per square meter 90 DAS 347.70 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+40kg S +10 Zn). The minimum number of effective tillers per square meter was recorded in control. These results are in agreement with the findings of Sriramchandrasekharan *et al*. (2004) [28], Yadav *et al*. (2006) [36], Shekara *et al*. (2011) [23], Shankar and Laware (2011) [27], Mahmud *et al*. (2011) and Singh *et al*. (2018).

Number of spikes ear^{-1}

As the data presented in the table (1) showed, there was a significant relationship among all the treatments. Highest number of spikes per ear 12.70 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+40kg S +10 Zn). The minimum number of spikes per ear was recorded in control. These results are in agreement with the findings of Shankar and Laware (2011) [27] and Mondal *et al*. (2007) [10].

Table 1: Growth parameter of rice

Treatments		Plant height (cm)				No. of hills/m^2	No. of tillers hill^{-1} at 30 DAT	No. of effective tillers/m^{-2} 90 DAT	No. of spikes ear^{-1}
		30 DAS	60 DAS	90 DAS	At harvest				
T_1	Control	31.82	62.95	83.99	95.00	39.93	8.47	282.98	6.35
T_2	100% RDF	36.47	66.32	86.48	96.86	45.18	9.22	309.13	9.52
T_3	100% RDF+20kg S	39.06	69.76	89.04	103.45	47.18	10.56	338.25	10.56
T_4	100% RDF+40kg S	39.78	70.91	89.85	104.05	48.31	10.80	350.20	10.68
T_5	100% RDF+5kg Zn	36.93	67.78	89.05	98.71	47.37	9.33	321.05	9.79
T_6	100% RDF+10 kg Zn	38.28	68.95	89.76	101.95	47.86	9.85	324.45	10.42
T_7	100% RDF+20kg S+5 kg Zn	40.20	71.55	91.14	105.26	48.50	11.40	358.83	11.00
T_8	100% RDF+40 kg S+10 kg Zn	40.74	72.84	91.53	105.83	48.98	11.60	364.35	11.52
T_9	100% RDF+Biofertilizer	35.83	67.29	86.33	97.42	46.83	9.25	314.75	9.75
T_{10}	100% RDF+20kg S+5 kg Zn+ Biofertilizer	41.23	73.31	92.30	106.46	49.00	12.40	368.15	11.67
T_{11}	100% RDF+40 kg S+10 kg Zn+Biofertilizer	41.90	74.02	92.53	107.03	49.60	12.63	374.70	12.70
S.Em ±		0.85	1.18	1.09	1.31	0.86	0.29	4.33	0.32
C.D. at 5%		2.42	3.37	3.10	3.74	2.45	0.84	12.38	0.90

Growth parameters of mustard

Plant height (cm) 30, 60, 90 & at harvest

As the data presented in the table (2) showed, there was a significant relationship among all the treatments. Highest plant height (cm) 30, 60, 90 DAS & at harvest (14.48 cm, 58.34 cm, 112.48 cm & 128.88 cm) was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum plant height was recorded in control. A similar result has been collaborated by Kashved *et al*. (2010) [8], Singh and Pal (2011) [24] and Singh *et al*. (2010).

Plant population per row (running meter)

As the data presented in the table (2) showed, there was a significant relationship among all the treatments. Highest plant population per row 14.26 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum plant population per row was recorded in control. These results are in close conformity with the findings of Baloch *et al*. (2006).

Number of primary, secondary and tertiary branches- 30, 60, and 90 DAS: As the data presented in the table (2) showed, there was a significant relationship among all the treatments. Highest number of primary branches at 30 DAS 5.96 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum number of primary branches at 30 DAS was recorded in control.

As the data presented in the table (2) showed, there was a significant relationship among all the treatments. Highest number of secondary branches at 60 DAS 13.72 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum number of secondary branches at 60 DAS was recorded in control. As the data presented in the table (2) showed, there was a significant relationship among all the treatments. Highest number of tertiary branches at 90 DAS 4.87 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum number of tertiary branches at 90 DAS was recorded in control. These results are in close conformity with Kashdev *et al*. (2010), Kumar *et al*. (2014), Dhruw *et al*. (2017) and Rajput *et al*. (2018).

Table 2: Growth parameters of mustard

Treatments		Plant height (cm)				Plant population row^{-1} 90 DAT	No. of primary branches 30 DAS	No. of secondary branches 60 DAS	No. of tertiary branches 90 DAT	No. of pod plnat^{-1}
		30 DAS	60 DAS	90 DAS	At harvest					
T_1	Control	8.38	36.95	102.90	119.44	8.98	3.09	8.87	9.26	270.75
T_2	100% RDF	11.56	41.65	108.08	125.58	12.30	4.04	12.00	12.3	332.11
T_3	100% RDF+20kg S	12.18	45.06	108.52	126.04	13.45	4.92	12.34	13.6	364.97
T_4	100% RDF+40kg S	12.21	48.66	110.05	126.05	13.70	5.44	12.46	13.68	365.90

T_5	100% RDF+5kg Zn	12.23	47.56	108.21	126.12	12.58	4.58	12.13	12.77	362.76
T_6	100% RDF+10 kg Zn	12.61	52.00	110.77	125.23	13.05	4.84	12.23	12.3	364.59
T_7	100% RDF+20kg S+5 kg Zn	12.08	52.99	109.14	127.75	13.64	5.33	12.42	12.65	365.40
T_8	100% RDF+40 kg S+10 kg Zn	12.84	55.42	112.40	128.19	13.79	5.55	13.21	13.4	366.50
T_9	100% RDF+Biofertilizer	13.19	47.12	107.81	125.97	12.46	4.39	12.11	12.7	350.51
T_{10}	100% RDF+20kg S+5 kg Zn+ Biofertilizer	14.18	56.35	112.07	128.23	14.05	5.68	13.59	13.74	367.54
T_{11}	100% RDF+40 kg S+10 kg Zn+Biofertilizer	14.48	58.34	112.48	128.88	14.26	5.96	13.72	13.9	367.89
S E±		0.31	0.79	1.05	1.05	0.42	0.23	0.26		8.29
C.D. at 5%		0.91	2.31	3.11	3.11	1.23	0.66	0.76		24.44

Number of pod plant^{-1}

As the data presented in the table (2) showed, there was a significant relationship among all the treatments. Highest number of pod per plant 367.89 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum number of pod plant^{-1} was recorded in control. These results are in close conformity with the findings of Amit Kumar and Sandeep Kumar (2011).

Yield attributes of rice

Length of ear (cm)

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the length of ear 28.31 cm 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+40kg S +10 Zn). The minimum length of ear was recorded in control. These results - are in close conformity with the findings of Singh and Pathak (2002) and Mondal *et al*. (2007) [10].

Number of grain ear^{-1}

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the number of grain per ear 194.42 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+40kg S +10 Zn). The minimum number of grain ear^{-1}was recorded in control. These results are in close conformity with the findings of Singh and Pathak (2002), Sriramachandrasekharan *et al.* (2004) [28], Yadav *et al.* (2006) [36] and Mondal *et al*. (2007) [10].

Grain weight/ ear (g):

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the grain weight per ear 6.80 g 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+40kg S +10 Zn). The minimum grain weight per ear was recorded in control. These results - are in close conformity with the findings of Gautam Kumar (1999), Ming-ming Wang (2010) [9] and Singh *et al.* (2013).

Test weight -1000 grains (g)

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the test weight -1000 grains 23.74 g 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+40kg S +10 Zn). The minimum test weight -1000 grains was recorded in control. by Geeta Devi *et al.* (2000), Sarfraz *et al.* (2002), Tripathi and Tripathi (2004), Yadav *et al.* (2006) [36] and Mahmud *et al*. (2016).

Bundle weight /plot (kg)

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the bundle weight per plot 22.15 kg 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+40kg S +10 Zn). The minimum bundle weight per plot was recorded in control. The finding of the present investigation is supported by

Grain weight /plot (kg)

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the grain weight per plot 8.58 kg 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+40kg S +10 Zn). The minimum grain weight per plot **(**kg) was recorded in control. The finding of the present investigation is supported by Ming-ming Wang (2010) [9] and Singh *et al.* (2013).

Biological yield (q ha-^{1})

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the biological yield 184.59 q ha-^{1} 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+40kg S +10 Zn). The minimum biological yield (q ha-^{1}) was recorded in control. The results of this study are in agreement with these followed workers OQ *et al.* (2007), Priyanka *et al.* (2013) Mahmud *et al*. (2016).

Table 3: Yield parameters of rice

Treatments of rice		Length of ear (cm)	No. of grain ear^{-1}	Grain weight ear^{-1} (g)	Test weight 1000 grains (g)	Bundle weight plot^{-1} (kg)	Grain weight plot^{-1} (kg)	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Harvest index (%)
T_1	Control	20.68	134.50	3.52	16.47	10.41	3.84	86.73	32.03	84.99	36.93

T_2	100% RDF	23.46	141.45	4.30	18.13	16.50	6.30	137.46	52.48	94.56	38.18
T_3	100% RDF+20kg S	25.19	156.65	4.34	20.43	18.40	7.06	153.36	58.80	99.71	38.34
T_4	100% RDF+40kg S	25.24	172.14	4.32	20.81	19.43	7.47	161.94	62.23	88.68	38.43
T_5	100% RDF+5kg Zn	23.76	146.46	4.93	18.40	17.24	6.60	143.68	55.00	90.93	38.28
T_6	100% RDF+10 kg Zn	24.89	154.42	5.19	19.47	17.70	6.79	147.48	56.55	105.34	38.35
T_7	100% RDF+20kg S+5 kg Zn	25.52	179.61	6.23	21.28	20.56	7.92	171.36	66.03	108.39	38.53
T_8	100% RDF+40 kg S+10 kg Zn	26.24	187.53	6.63	21.93	21.18	8.18	176.51	68.13	87.48	38.60
T_9	100% RDF+Biofertilizer	23.53	144.79	5.93	18.95	17.04	6.52	141.98	54.30	111.58	38.25
T_{10}	100% RDF+20kg S+5 kg Zn+ Biofertilizer	27.21	191.82	6.67	23.49	21.82	8.43	181.83	70.25	113.09	38.64
T_{11}	100% RDF+40 kg S+10 kg Zn+Biofertilizer	28.31	194.42	6.80	23.74	22.15	8.58	184.59	71.50	84.99	38.74
S E±		0.49	2.77	0.20	0.30	0.43	0.29	3.91	0.93	2.87	0.11
C.D. at 5%		1.40	7.93	0.58	0.85	1.24	0.83	11.15	2.67	8.19	0.32

Grain yield (q ha^{-1})

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the grain yield 71.50 q ha^{-1} 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+40kg S +10 Zn). The minimum grain yield (q ha^{-1}) was recorded in control. The finding of the present investigation is supported by Sharma and Bapat (2000), Tripathi and Tripathi (2004), Nagdive *et al.* (2007), Singh *et al*. (2017) and Keerthi *et al*. (2018).

Straw yield (q ha^{-1}):

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the straw yield 113.09 q ha^{-1} 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+40kg S +10 Zn). The minimum straw yield (q ha^{-1}) was recorded in control. The results of this study are in agreement with these followed workers Sriramachandrasekharan *et al.* (2004) [28] and Tripathi *et al*. (2010)

Harvest index (%)

As the data presented in the table (3) showed, there was a significant relationship among all the treatments. Highest the harvest index 38.74% 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+40kg S +10 Zn). The minimum harvest index percent was recorded in control. These results are by the findings of Mohd and Bhat (2005) and Singh *et al.* (2018).

Yield attributes of mustard

Number of grains pod^{-1}

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the number of grains per pod 13.53 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum number of grains per pod was recorded in control. These results are in close conformity with the findings of Razaq *et al*. (2011)

Test weight-1000 grains (g)

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the test weight-1000 grains 4.38 g was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum test weight-1000 grains were recorded in control. The finding of the present investigation is supported by Kumar *et al.* (2014), Dhruw *et al*. (2017) and Amit Kumar and Sandeep Kumar (2011).

Number of pod plant^{-1}, Grain weight/ plot (g), Bundle weight/plot (kg) and Stover yield per plot (kg)

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the number of pod per plant 367.89 was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum number of pod per plant was recorded in control.

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the grain weight per plot 2.56 g was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum grain weight per plot was recorded in control.

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the bundle weight per plot 9.32 g was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum bundle weight per plot was recorded in control.

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the stover yield per plot 4.30 kg was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum stover yield per plot (kg) was recorded in control. These results are in close conformity with the findings of Muhammad Arifullah *et al.* (2012) and Singh *et al.* (2013).

Biological yield (q ha^{-1})

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the biological yield 77.63 q ha^{-1} was recorded in T_{11}

Table 4: Yield parameter of rice

Treatments		No. of grain pod^{-1}	Test weight 1000 grains (g)	No. of pod plant^{-1}	Grain weight plot^{-1} (kg)	Bundle weight plot^{-1} (kg)	Stover yield plot^{-1} (kg)	Biological yield (q ha^{-1})	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T_1	Control	8.89	2.85	270.75	1.07	4.13	3.34	34.42	8.93	25.49	25.93
T_2	100% RDF	12.31	3.72	332.11	1.87	6.99	3.67	58.25	14.56	42.69	26.71
T_3	100% RDF	12.80	3.90	364.97	1.98	8.56	3.87	61.31	16.48	44.83	26.88

T_4	100% RDF	13.08	3.98	365.90	2.26	8.38	3.90	69.81	18.84	50.97	26.99
T_5	100% RDF	12.60	3.77	362.76	1.85	6.93	3.80	57.75	15.38	41.87	26.68
T_6	100% RDF	12.73	3.86	364.59	1.93	7.19	3.86	59.92	16.06	43.86	26.80
T_7	100% RDF	12.90	3.93	365.40	2.10	7.78	4.03	64.87	17.48	47.39	26.94
T_8	100% RDF	13.19	4.14	366.50	2.37	8.73	4.25	72.72	19.74	52.98	27.15
T_9	100% RDF	12.50	3.74	350.51	1.79	6.78	3.80	56.50	14.94	41.56	26.44
T_{10}	100% RDF	13.30	4.17	367.54	2.44	8.93	4.26	74.38	20.31	54.07	27.30
T_{11}	100% RDF	13.53	4.38	367.89	2.56	9.32	4.30	77.63	21.31	56.29	27.45
S E±		0.26	0.12	8.29	0.11	0.27	0.07	1.02	0.43	0.67	0.11
C.D. at 5%		0.78	0.35	24.44	0.33	0.78	0.19	2.91	1.26	1.90	0.32

(100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum biological yield (q ha-^{1}) was recorded in control. The result of these studies is in agreement with these followed workers Kashved *et al.* (2010) [8] and Kumar *et al.* (2014).

Grain yield (q ha-^{1})

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the grain yield 21.31 q ha^{-1} was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum grain yield (q ha-^{1}) was recorded in control. The finding of the present investigation is supported by Dhruw *et al*. (2017), Chauhan *et al*. (2018) and Solanki *et al*. (2018).

Stover yield (q ha-^{1})

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the stover yield 56.29 q ha^{-1} was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum stover yield (q ha-^{1}) was recorded in control. The finding of the present investigation is supported by Singh *et al*. (2010), Keerthi *et al*. (2018) and Rajput *et al*. (2018).

Harvest index (%)

As the data presented in the table (4) showed, there was a significant relationship among all the treatments. Highest the harvest index 27.45% was recorded in T_{11} (100% RDF) followed by T_{10} (100% RDF) and T_8 (100% RDF). The minimum harvest index percent was recorded in control. These results are in accordance with the findings of Chandel *et al.* (2003) [3], Mohd and Bhat (2005) and Rajput *et al*. (2018).

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