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Effect of integrated zinc and sulphur with vermicompost and nutrients on growth, yield attribute, yield and quality of wheat crop in alluvial soil

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Abstract

A field experiment was conducted at Agricultural Research farm of R.B.S. College Bichpuri, (Agra) during rabi seasons of 2021-22 and 2022-23 to study the impact of vermicompost and fertilizers nutrients on growth, yield attribute and yield of wheat crop in alluvial soil. The experiment was laid out in randomized block design with three levels of vermicompost (control, 2.5, and 5.0 t ha^{-1}) and four levels of fertilizer nutrients (control, 40 kg S ha^{-1}, 5 kg Zn ha^{-1} and 40 kg S + 5 kg Zn ha^{-1}). The results revealed that the application of to 5.0 t ha^{-1} vermicompost significantly increased the no. of tillers meter^{-1}, plant height, length of ear, no. of spikelet ear^{-1}, no. of grain ear^{-1}, test weight, grain yield, straw yield and biological yield by 17.4, 9.4, 11.5, 20.9, 24.6, 15.6, 18.8, 19.2 and 19.0 percent, respectively, over control pooled data of two years. Application of 40 kg S + 5 kg Zn ha^{-1} proved superior to the control with respect to no. of tillers meter^{-1}, plant height, length of ear, no. of spikelet ear^{-1}, no. of grain ear^{-1}, test weight, grain yield, straw yield and biological yield by 21.0, 12.5, 20.7, 24.0, 24.0, 19.0, 19.7, 24.3 and 22.5 percent, respectively pooled data of two years.

Key words: Vermicompost, tillers, grain yield, biological yield, spikelet

Introduction

Wheat (*Triticum aestivum L.)* is exhaustive feeder and requires substantial amount of nutrients for higher productivity. Wheat is a good supplement for nutritional requirement of human body as it contains 9-10% proteins and 60-80 % carbohydrates. Maintaining soil organic matter is a prerequisite to ensure soil health and crop productivity of crop residue based amendment in soil is an important strategy to improve the soil fertility and productivity in rain fed areas. These residues are either partially utilized or un-utilized due to various constraints. Deficiencies of S and Zn are quite wide spread in Indian soils. Sulphur deficiency is observed primarily due to high crop yield and therefore higher rates of S removal by crop and lesser use of sulphur containing fertilizers. Sulphur is one of the nutrients essential to plant growth. It ranks in importance with nitrogen and phosphorus in the formation of proteins and is involved in the metabolic and enzymic processes of all living cells. It is required for the synthesis of sulphur containing amino acids, cysteine, cysteine and methionine and protein. Zinc plays a key role as structural constituent or regulatory cofactors of wide range of different enzymes and proteins in most important biochemical pathways. These are mainly concerned with carbohydrate metabolism both in the conversion of sugars to starch, protein, metabolism, auxin, metabolism, pollen formation, the maintenance of the integrity of biological membranes, the resistance to infection by certain pathogens Zinc deficiency is a common phenomenon in cereals, and oil seed crop, particularly in coarse texture soil of semi-arid regions. The responses of vermicompost and nutrient differed widely among the crops and their cultivars because of wide variations in sensitivity to nutrients stress and soil types. The information regarding the differential behavior of crops to vermicompost and nutrients under identical soil and water conditions is considered to be of interest. However, no systematic informative is available on the response of these crops to vermicompost and nutrients in alluvial soil.

Materials and Methods

A field experiment was conducted at the Agricultural Research farm of R.B.S College Bichpuri Agra (U.P.) India during Rabi seasons of 2021-2022 and 2022-23. The experimental site is characterized by semi arid climate with extreme temperature during summer (45^0 to 48^0 C) and very low temperature during winter (as low 2^0C). The average rainfall is about 650 mm received from June to September. The soil of the experimental site is sandy loam in texture having EC 0.17 dSm^{-1}, pH 8.1, organic carbon 4.5 g kg^{-1}, available N 194.7, P 13.8 and K 212.4 kg ha^{-1}. The soil had $CaCl_2$ extractable sulphur content of 15.3 kg ha^{-1} and DTPA extractable zinc 0.57 mg kg^{-1}. The experiment was laid out in randomized block design with three levels of vermicompost (control, 2.5, and 5.0 t ha^{-1}) and four levels of fertilizer nutrients (control, 40 kg S ha^{-1}, 5 kg Zn ha^{-1} and 40 kg S + 5 kg Zn ha^{-1}) with three replications. Recommended dose of N, P, K, fertilizers for wheat is N 150, P 60 and K40 ha^{-1} respectively. The half of N and full amount of P, K, S and Zn as per treatments were applied at time of sowing and remaining N was top dressed at two stages in equal amount. The source N, P_2O_5 K_2O, S and Zn were applied as urea, single super phosphate, muriate of potash and zinc sulphate respectively. Vermicompost (1.05 %N, 0.88% P and 1.81% K) were applied before 15 days of sowing. The wheat crop was sown in the third week of November during both the years using @ 120.0 kg seed ha^{-1}. The crop was harvested at physiological maturity and grain and straw yields were recorded. The observations on growth and yield attributes were recorded at harvest.

Results and discussion

Number of tillers meter^{-1}

The data presented in (Table 1) Number of tillers meter^{-1} row length of wheat crop (81.8, 82.3 and 82) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by 2.5 t ha^{-1} (75.3, 77.3 and 76.3) compared to control (69.2 70.5 and 69.8) at both the years and pooled analysis. Thus, the increase in the number of tillers meter^{-1} row length of wheat crop with V1 and V2 vermicompost levels was 8.9, 9.6, 9.2 and 18.2, 16.7, 17.4 %, respectively over control at both the years and pooled analysis. These results are in agreement with the opinion of Veena and Pareek (2007) and Yadav et al. (2018). Further it is clear

Table 1: Effect of integrated zinc and sulphur with vermicompost on no. of tillers and plant height of wheat crop

Treatments	No. of tillers (M^{-1})			Plant height (cm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Vermicompost (t ha^{-1})						
V_0	69.2	70.5	69.8	85.48	88.91	87.20
V_1	75.3	77.3	76.3	89.94	93.32	91.63
V_2	81.8	82.3	82.0	93.57	97.25	95.41
SEm±	0.53	1.80	1.25	1.78	2.23	1.21
CD @ 5%	1.10	3.73	2.58	3.68	4.61	2.50
Fertilizers nutrients (kg ha^{-1})						
F_0	68.9	69.4	69.2	84.88	86.97	85.92
F_1	76.1	77.6	76.8	90.87	94.55	92.71
F_2	73.8	75.1	74.4	88.43	92.28	90.35
F_3	82.9	84.6	83.7	94.47	98.85	96.66
SEm±	0.61	2.08	1.44	2.05	2.57	1.40
CD @ 5%	1.27	4.31	2.98	4.25	5.32	2.89

from (Table 1) that the number of tillers meter^{-1} row length of wheat crop increased affected significantly by the levels of fertilizer nutrients at both the years and pooled analysis. The number of tillers meter^{-1} row length of wheat crop increased significantly with each fertilizer nutrients treatment as compared to control. The number of tillers meter^{-1} row length of wheat crop (82.9, 84.6, 83.7) was observed significantly higher with the application of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (76.1, 77.6, 76.8) and F2 @ 5 kg Zn ha^{-1} (73.8, 75.1, 74.4) and compared to control (68.9, 69.4, 69.2) no application of fertilizer nutrients. On the basis of pooled data of two years, the increase in the number of tillers meter^{-1} row length of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 7.1, 8.2, 7.6 and 10.5, 11.7, 11.1 and 20.3, 21.8, 21.0% compared to control respectively. These findings are Goswami and Pandey (2018), Vora et al. (2019) and Singh et al. (2020)

Plant height:

In the present study (Table 1) the plant height of wheat crop increased significantly with each levels of vermicompost as compared to control. Plant height of wheat crop (93.57, 97.25 and 95.41) was observed to be significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by 2.5 t ha^{-1} (89.84, 93.32 and 91.63 kg ha^{-1}) compared to control (85.48, 88.91 and 87.20 kg ha^{-1}) at both the years and pooled analysis. The respective increase in plant height with application of vermicompost @ 2.5, and 5 t ha^{-1} levels was 5.2, 5.0, 5.1 and 9.5, 9.4, 9.4 %, respectively over the control during the pooled data of the two years. These results are in agreement with the opinion of Yadav et al. (2018). Further, it is clear from the (Table 1) that the plant height of wheat crop (94.47, 98.85 and 96.66) was observed to be significantly higher with the application of fertiliser nutrients (F3) 40 kg S+ 5 kg Zn ha^{-1} followed by (F1) 40 kg S ha^{-1} (90.87, 94.55 and 92.71) and (F2) 5 kg Zn ha^{-1} (88.43, 92.28 and 90.35) and compared to control (84.88, 86.97 and 85.92). The respective increase in plat height of wheat crop with application of fertilizer nutrients (F2) 5 kg Zn ha^{-1}, (F1) 40 kg S ha^{-1} and (F3) 40 kg S+5 kg Zn ha^{-1} levels was 4.2, 6.1, 5.2 and 7.1, 8.7, 7.9 and 11.3, 13.7, 12.5% respectively over the control. Our findings are in agreement with those of Singh and Pandey (2018) Goswami and Pandey (2018), Vora et al. (2019) and Singh et al. (2020).

Length of ear

The data presented in (Table 2) reveal that the length of ear (cm) of wheat crop (8.80, 8.98 and 8.89) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by

Table 2: Effect of integrated zinc and sulphur with vermicompost on length of ear and no. of spikelet of wheat crop

Treatments	Length of ear (cm)			No. of spikelet ear^{-1}		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Vermicompost (t ha^{-1})						
V_0	7.95	8.07	8.01	15.2	16.2	15.7
V_1	8.39	8.63	8.51	16.9	17.7	17.3
V_2	8.80	8.98	8.89	18.5	19.5	19.0
SEm±	0.202	0.200	0.136	0.69	0.53	0.43
CD @ 5%	0.419	0.414	0.281	1.32	1.10	0.89
Fertilizers nutrients (kg ha^{-1})						
F_0	7.77	7.84	7.81	15.4	16.0	15.7
F_1	8.45	8.51	8.48	17.1	18.0	17.5
F_2	8.09	8.23	8.16	16.2	17.0	16.6
F_3	9.20	9.65	9.43	18.6	20.3	19.5
SEm±	0.234	0.231	0.157	0.74	0.61	0.50
CD @ 5%	0.484	0.478	0.324	1.52	1.27	1.03

2.5 t ha^{-1} (8.39, 8.63 and 8.51) compared to control (7.95, 8.07 and 8.01) at both the years and pooled analysis. Thus, the increase in the length of ear (cm) of wheat crop with V1 and V2 vermicompost levels was 5.5, 7.0, 6.2 and 10.7, 11.3, 11 %, respectively over control at both the years and pooled analysis. These findings are Yadav et al. (2018). Further it is clear from (Table-2) the length of ear (cm) of wheat crop (9.20, 9.65 and 9.43) was recorded significantly higher with the application of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (8.45, 8.51 and 8.48) and F2 @ 5 kg Zn ha^{-1} (8.09, 8.23 and 8.16) and compared to control (7.77, 7.84 and 7.81) no application of fertilizer nutrients. The respective increase in the length of ear (cm) of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 4.1, 4.9, 4.5 and 8.7, 8.5, 8.6 and 18.4, 23.0, 20.7% compared to control respectively at both the years and pooled analysis. These results are Vora et al. (2019) and Singh et al. (2020).

Number of spikelet ear^{-1}

The data presented in (Table 2) reveal that the number of spikelet ear^{-1} of wheat crop (18.5, 19.5 and 19.0) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by @ 2.5 t ha^{-1} (16.9, 17.7 and 17.3) compared to control (15.2, 16.2 and 15.7) at both the years and pooled analysis. Thus, the increase in the number of spikelet $ear^{-1}$of wheat crop with V1 and V2 vermicompost levels was 11.0, 9.1, 10.0 and 21.7, 20.1, 20.9%, respectively over control at both the years and pooled analysis. These results are Yadav et al. (2018). Further it is clear from (Table 2) that the number of spikelet ear^{-1} of wheat crop (18.6, 20.3 and 19.5) was recorded significantly higher with the application of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (17.1, 18.0 and 17.5) and F2 @ 5 kg Zn ha^{-1} (16.2, 17.0 and 16.6) and compared to control (15.4, 16.0 and 15.7) no application of fertilizer nutrients. The respective increase in the number of spikelet ear^{-1} of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 5.0, 6.5, 5.8 and 10.7, 12.6, 11.7 and 20.7, 27.1, 24.0% compared to control respectively at both the years and pooled analysis. Similar results were also reported by Vora et al. (2019) and Singh et al. (2020).

No. of grain ear^{-1}

It is evident from (Table 3) that the number of number of grain $ear^{-1}$of wheat crop (42.5, 45.4 and 44.0) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by @ 2.5 t ha^{-1} (39.2, 40.6 and 39.9) compared to control (35.5, 35.1 and 35.3) at both the years and pooled analysis. Similarly, the enhancement in

Table 3: Effect of integrated zinc and sulphur with vermicompost on grain ear^{-1} and test weight of wheat crop

Treatments	Grain ear^{-1} (gm)			Test weight (gm)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Vermicompost (t ha^{-1})						
V_0	35.5	35.1	35.3	41.9	42.7	42.3
V_1	39.2	40.6	39.9	44.9	46.0	45.5
V_2	42.5	45.4	44.0	48.5	49.4	48.9
SEm±	0.674	0.851	0.534	0.75	0.63	0.55
CD @ 5%	1.394	1.761	1.106	1.55	1.30	1.14
Fertilizers nutrients (kg ha^{-1})						
F_0	35.3	36.1	35.7	41.4	42.3	41.8
F_1	39.9	40.8	40.3	45.8	46.7	46.2
F_2	38.0	39.0	38.5	43.9	44.9	44.4
F_3	43.0	45.6	44.3	49.4	50.2	49.8
SEm±	0.778	0.983	0.617	0.87	0.73	0.63
CD @ 5%	1.610	2.033	1.277	1.79	1.50	1.31

number of grain ear^{-1} of wheat crop with V1@ 2.5 t ha^{-1} and V2 @ 5 t ha^{-1} levels of vermicompost over control was 10.3, 15.7, 13.0 and 19.7, 29.5, 24.6%, respectively during pooled data of two years. These results are in agreement with the opinion of Chandan et al. (2018) and Yadav et al. (2018). Further, it is clear from (Table-3) that the number of grain ear^{-1} of wheat crop (43.0, 45.6 and 44.3) was recorded significantly higher with the application of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (39.9, 40.8 and 40.3) and F2 @ 5 kg Zn ha^{-1} (38.0, 39.0 and 38.5) and compared to control (35.3, 36.1 and 35.7) no application of fertilizer nutrients. On the basis of pooled data of two years, the increases in number of grain ear^{-1} of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} over control were 7.5, 8.0, 7.8 and 12.9, 12.9, 12.9 and 21.7, 26.2, 24%. These results are in favor of Goswami and Pandey (2018) Vora et al. (2019) Singh et al. (2020)

Test weight

The data presented in (Table 3) reveal that the test weight (gm) of wheat crop (48.5, 49.4 and 48.9) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by @ 2.5 t ha^{-1} (44.9, 46.0 and 45.5) compared to control (41.9, 42.7 and 42.3) at both the years and pooled analysis. Thus, the increase in test weight (gm) of wheat crop with V1@ 2.5 t ha^{-1} and V2 @ 5 t ha^{-1} levels of vermicompost was 7.1, 7.8, 7.4 and 15.5, 15.7, 15.6%, respectively over control at both the years and pooled analysis. Similar results were also reported Chandan et al. (2018) and Yadav et al. (2018). Further it is clear from (Table-3) the test weight (gm) of wheat crop (49.4, 50.2 and 49.8) was recorded significantly higher with the application of fertiliser nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (45.8, 46.7 and 46.2) and F2 @ 5 kg Zn ha^{-1} (43.9, 44.9 and 44.4) and compared to control (41.4, 42.3 and 41.8) no application of fertilizer nutrients. The respective increase in the test weight (gm) of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 6.0, 6.3, 6.2 and 10.7, 10.4, 10.5 and 19.3, 18.7, 19.0% compared to control respectively at both the years and pooled analysis. Similar results were also reported by Goswami and Pandey (2018) and Vora et al. (2019).

Grain Yield

The data recorded to grain yield q ha^{-1} of wheat crop has been summarized in (Table 4) reflect that the grain yield of wheat crop (48.3, 50.9 and 49.6 q ha^{-1}) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by V1 @ 2.5 t ha^{-1} (44.8, 46.4 and 45.6 q ha^{-1}) compared to control (40.7, 42.8 and 41.8 q ha^{-1}) at

Table 4: Effect of integrated zinc and sulphur with vermicompost on grain yield, straw yield and biology yield of wheat crop

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Biological yield (q ha^{-1})		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Vermicompost (t ha^{-1})									
V_0	40.7	42.8	41.8	62.8	64.1	63.5	103.5	107.0	105.2
V_1	44.8	46.4	45.6	68.3	70.2	69.3	113.1	116.6	114.9
V_2	48.3	50.9	49.6	74.3	77.0	75.6	122.6	127.9	125.2
SEm±	1.73	1.58	1.14	1.93	2.13	1.45	2.62	2.41	1.72
CD @ 5%	3.58	3.26	2.36	3.99	4.41	2.99	5.42	4.98	3.56
Fertilizers nutrients (kg ha^{-1})									
F_0	40.8	42.6	41.7	61.9	63.3	62.6	102.8	105.9	104.3
F_1	45.1	47.1	46.1	68.7	71.3	70.0	113.7	118.4	116.0
F_2	43.9	46.0	45.0	66.5	68.2	67.4	110.4	114.2	112.3
F_3	48.7	51.2	49.9	76.7	79.0	77.9	125.3	130.2	127.8
SEm±	1.10	1.82	1.32	2.23	2.46	1.67	3.03	2.78	1.99
CD @ 5%	4.13	3.77	2.73	4.61	5.10	3.46	6.26	5.75	4.11

both the years and pooled analysis. Thus, the increase grain yield of wheat crop with V1@ 2.5 t ha^{-1} and V2 @ 5 t ha^{-1} levels of vermicompost was 10.2, 8.3, 9.2 and 18.7, 18.8, 18.8%, respectively over control at both the years and pooled analysis. These results are in agreement with opinion of Yadav et al. (2018) and Maurya et al. (2019) Further it is clear from the (Table 4) that the grain yield of wheat crop (48.7, 51.2 and 49.9 q ha^{-1}) was recorded significantly higher with the application of fertiliser nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (45.1, 47.1 and 46.1 q ha^{-1}) and F2 @ 5 kg Zn ha^{-1} (43.9, 46.0 and 45.0 q ha^{-1}) and compared to control (40.8, 42.6 and 41.7 q ha^{-1}) at both the years and pooled analysis. The respective increase in the grain yield of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 7.5, 8.0, 7.8 and 10.4, 10.6, 10.5 and 19.2, 20.2, 19.7% compared to control respectively at both the years and pooled analysis. Over findings are in agreement with those of Kumar et al. (2003) and Chaube et al. (2007)

Stover yield

It is evident from (Table 4) reveal that the maximum straw yield of wheat crop was recorded under highest level of vermicompost V2 @ 5 t ha^{-1}. The straw yield of wheat crop (74.3, 77.0 and 75.6 q ha^{-1}) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by V1 @ 2.5 t ha^{-1} (68.3, 70.2 and 69.3 q ha^{-1}) compared to control (62.8, 64.1 and 63.5q ha^{-1}) at both the years and pooled analysis. The percent increase in straw yield of wheat crop due to F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} levels over control were 8.7, 9.5, 9.1 and 18.2, 20.1, 19.2% respectively during both the years and pooled analysis. These results are in favor of Yadav et al. (2018) and Maurya et al. (2019). The data presented in (Table 4) further reveal that the straw yield of wheat crop (76.7, 79.0 and 77.9 q ha^{-1}) was recorded significantly higher with the application of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (68.7, 71.3 and 70.0 q ha^{-1}) and F2 @ 5 kg Zn ha^{-1} (66.5, 68.2 and 67.4 q ha^{-1}) and compared to control (61.9, 63.3 and 62.6 q ha^{-1}) at both the years and pooled analysis. The present increased in straw yield of wheat crop due to F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 7.4, 7.7, 7.6 and 10.9, 12.5, 11.7 and 23.8, 24.8, 24,3% in comparison to control, respectively during both the years and pooled analysis. These results are in accordance with those of Kumar et al. (2003) and Chaube et al. (2007).

Biological yield

The data recorded to biological yield q ha^{-1} of wheat crop has been summarized in (Table 4) reflect that the levels of vermicompost affected significantly the biological yield of wheat crop. The biological yield of wheat crop (122.6, 127.9 and 125.2 q ha^{-1}) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by V1 @ 2.5 t ha^{-1} (113.1, 116.6 and 114.9 q ha^{-1}) compared to control (103.5, 107.0 and 105.2 q ha^{-1}) at both the years and pooled analysis. Thus, the increase biological yield of wheat crop with V1@ 2.5 t ha^{-1} and V2 @ 5 t ha^{-1} levels of vermicompost was 9.3, 9.0, 9.2 and 18.4, 19.6, 19.0%, respectively over control at both the years and pooled analysis. These results are in agreement with opinion of Yadav et al. (2018). Further it is clear from the (Table 4) that the biological yield of wheat crop (125.3, 130.2 and 127.8 q ha^{-1}) was recorded significantly higher with the application of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (113.7, 118.4 and 116.0 q ha^{-1}) and F2 @ 5 kg Zn ha^{-1} (110.4, 114.2 and 112.3 q ha^{-1}) and compared to control (102.8, 105.9 and 104.3 q ha^{-1}) at both the years and pooled analysis. The respective increase in the biological yield of wheat crop with F2 @ 5 kg Zn ha^{-1}, F1@ 40 kg S ha^{-1} and F3 @ 40 kg S+5 kg Zn ha^{-1} were 7.5, 8.0, 7.8 , 7.7 and 10.7, 11.7, 11.2 and 22.0, 23.0, 22.5% compared to control respectively at both the years and pooled analysis. Over findings are in agreement with those of Yadav et al. (2018) and Maurya et al. (2019).

Protein content in grain

It could be inferred from (Table 5) that the maximum protein content in grain of wheat crop was noted under highest level of vermicompost V2 @ 5 t ha^{-1} compared to control. The protein content in grain of wheat crop (12.93, 13.30 and 13.12%) was recorded significantly higher with the application of

Table 5: Effect of integrated zinc and sulphur with vermicompost on protein content of wheat crop

Treatments	Protein content in grain (%)			Protein content in straw (%)		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Vermicompost (t ha^{-1})						
V_0	11.15	11.36	11.26	3.09	3.16	3.13
V_1	11.98	12.25	12.11	3.35	3.43	3.39
V_2	12.93	13.30	13.12	3.68	3.96	3.82
SEm±	0.300	0.251	0.215	0.163	0.136	0.118
CD @ 5%	0.622	0.520	0.444	0.337	0.281	0.245
Fertilizers nutrients (kg ha^{-1})						
F_0	11.12	11.34	11.23	3.05	3.13	3.09
F_1	12.15	12.42	12.29	3.43	3.59	3.51
F_2	11.81	12.18	12.00	3.30	3.48	3.39
F_3	13.01	13.27	13.14	3.71	3.87	3.79
SEm±	0.347	0.290	0.248	0.188	0.157	0.137
CD @ 5%	0.718	0.600	0.513	0.389	0.324	0.283

vermicompost @ 5 t ha^{-1} followed by V1 @ 2.5 t ha^{-1} (11.98, 12.25 and 12.11%) compared to control (11.15, 11.36 and 11.26%) respectively, at both the years and pooled analysis. Similar to these findings are Yadav et al. (2018). The data given in (Table-5) clearly shows that protein content in grain of wheat crop increased significantly with increasing levels of fertilizer nutrients at both the years of experimentation and pooled analysis. The protein content in wheat crop (13.01, 13.27 and 13.14%) was recorded significantly higher with the application of fertiliser nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (12.15, 12.42 and 12.29%) and F2 @ 5 kg Zn ha^{-1} (11.81, 12.18 and 12.00%) and compared to control (11.12, 11.34 and 11.23%) at both the years of experimentation and pooled analysis.

Protein content in straw

It could be inferred from (Table 5) that the protein content in straw of wheat crop increased significantly with increasing levels of vermicompost during both the years of experimentation and pooled analysis. The protein content in straw of wheat crop (3.68, 3.96 and 3.82%) was recorded significantly higher with the application of vermicompost @ 5 t ha^{-1} followed by V1 @ 2.5 t ha^{-1} (3.35, 3.43 and 3.39%) compared to control (3.09, 3.16 and 3.13%) respectively at both the years of experimentation and pooled analysis. The data given in (Table-5) clearly shows that the maximum protein content in straw of wheat crop was noted under highest level of fertilizer nutrients F3 @ 40 kg S+5 kg Zn ha^{-1}. The protein content in straw of wheat crop (3.71, 3.87 and 3.79%) was recorded significantly higher with the application of fertiliser nutrients F3 @ 40 kg S+5 kg Zn ha^{-1} followed by F1@ 40 kg S ha^{-1} (3.43, 3.59 and 3.51%) and F2 @ 5 kg Zn ha^{-1} (3.30, 3.48 and 3.39%) and compared to control (3.05, 3.13 and 3.09%) at both the years of experimentation and pooled analysis, respectively. Similar to these findings are Yadav et al. (2018).

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