The Pharma Innovation Journal 2022; 11(11): 2507-2511

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(11): 2507-2511

www.thepharmajournal.com
Received: 16-09-2022
Accepted: 23-10-2022

Ravendra Kumar Agnihotri
Bhagwant University, Ajmer, Rajasthan, India

Atin Kumar
Bhagwant University, Ajmer, Rajasthan, India

Mahendra Nagar
Bhagwant University, Ajmer, Rajasthan, India

Sandeep Kumar
Bhagwant University, Ajmer, Rajasthan, India

Abhishek Tiwari
Babasaheb Bhimrao Ambedkar University (A Central University), Lucknow, Uttar Pradesh, India

Corresponding Author:
Ravendra Kumar Agnihotri
Bhagwant University, Ajmer, Rajasthan, India

Effect of various nutrient management modules on growth, yield and quality of wheat

Ravendra Kumar Agnihotri, Atin Kumar, Mahendra Nagar, Sandeep Kumar and Abhishek Tiwari

Abstract
The field experiment was conducted during *Rabi* 2014-15 and 2015-16 at Student's Instructional Farm of Bhagwant University, Ajmer, Rajasthan. The experiment was carried out in Randomized Block Design (RBD) having three replications and fourteen integrated nutrient management module combinations. The treatments T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20kg $ZnSO_4$ ha^{-1}, T_3: RDF + 5 t FYM ha^{-1}, T_4: RDF + 2.5 t VC ha^{-1}, T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF(112.50:50:45 kg ha^{-1}), T_8: 75% RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75% RDF + 10 t FYM ha^{-1}, T_{10}: 75% RDF + 5 t VC ha^{-1}, T_{11}: 75% RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75% RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125% RDF (187.50:75:50 kg ha^{-1}), T_{14}: 125% RDF + 20 kg $ZnSO_4$ ha^{-1} The Pooled data of *rabi* 2014-15 and 2015-16, Maximum growth, yield attributes and yield of wheat crop were recorded under the nutrient management module T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}) closely followed by T_5 (100% RDF+5 t FYM+20 kg $ZnSO_4$ ha^{-1}). Significantly higher grain and straw yield were recorded under treatment having T_6 (100% RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) over T_1 (100% RDF). The significant differences were found in case of protein content also. The highest value of pooled protein content was recorded in treatment T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}). On the basis of results summarized above, it may be concluded that nutrient management module 100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1} proved best for improving nutrient uptake, yield attributes and yield of wheat as well as soil properties. Also the highest net return was recorded in the same treatment. Therefore, the nutrient management module 100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1} may safely be recommended for growing of wheat in eastern part of Rajasthan.

Keywords: FYM, vermicompost, sulphur, zinc, wheat

Introduction

The way India increased its wheat production and helped the food security system through "wheat revolution" is worth to be recommended. It was felt that the wheat revolution and green revolution have made it self-sufficient in food grains and there will be no going back to old import days when the food security was either "Ship to mouth" or "field to mouth". Wheat (*Triticum aestivum* L.) is one of the most important cereal crops of the world. Among the world's most important food grain, it ranks next to rice. It is eaten in various forms by more than one billion in the world. Wheat straw is a good source of feed for a large population of the cattle in our country. It has a relatively high content of niacin and thiamin that is why, wheat proteins are of special significance which are principally concerned in providing the 'gluten' which provides the frame work for sponge cellular texture of bread and baked products. It is primarily grown in temperate regions at high altitude as well as medium altitude in tropical and sub-tropical regions. It ranks first in the world among the cereals both in respect of acreage (221.50 m ha) and production (727.87 million metric t.) (Anonyms 2014-15). India is the second largest producer of wheat in the world. It is the second most important cereal crop after rice and this is a pre-dominant winter season crop of north western plain zones and during 2014-15 production in India was 95.85 million metric tons from an area of 30.47 million hectares with productivity of 3.15 metric tonnes ha-1 (Anonyms 2014-15). UP ranks first in respect of wheat crop coverage area (9.64 million hectares) and production (30.00 million tones) but average productivity is low (3.11 t ha-1) (Anonyms 2015-16).Farmyard manure is bulky organic manure resulting from decomposed mixture of dung and urine of farm animals. Application of FYM is of greater significance for sustainability as it has great potentiality to improve the physical properties of soil besides supplying nutrients. Each of these physical properties has large practical implication in maintaining soil as a medium of production and great role in halting environmental degradation. Maintaining and improving them in long run is essential part of sustaining the ecosystem.

Material and Methods

The field experiment was conducted during *Rabi* 2014-15 and 2015-16 at Student's Instructional Farm of Bhagwant University, Ajmer, Rajasthan. The experiment was carried out in Randomized Block Design (RBD) having three replications and fourteen integrated nutrient management module combinations. Geographically the experimental site is situated at 26.47^0 North latitude and 81.12^0 East longitude with an elevation of about 113 m from mean sea level in the Gangatic Plain Zone of Eastern Rajasthan,

Application of FYM and Vermicompost, Fertilizer application

Farm yard manure and Vermicompost as per treatment were incorporated uniformly in the plots before 15 days of sowing of wheat. N, P_2O_5 and K_2O *i.e.*, @ 150, 60 and 40 kg ha^{-1}, respectively was considered as 100% recommended dose of fertilizer. Nitrogen was applied in splits through urea. Full dose of phosphorus, potassium and half dose of nitrogen were applied at the time of sowing and rest half dose of nitrogen was applied in two split doses at the time of first irrigation and second irrigation. Basal application of phosphorus and potassium was made through DAP and MOP, respectively as per treatment.

Results and Discussion

Growth, yield contributing characters, yield and quality of wheat

1. The maximum plant height was recorded under the treatment T_6 (100% RDF+2.5 t VC+20kg $ZnSO_4$ha^{-1}) which was significantly superior over T_1 (100% RDF) at all the growth stages except at 30 DAS.
2. The maximum chlorophyll content in leaves was also recorded under the treatment receiving T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}) which was significantly superior over T_1 (100% RDF) at all the growth stages except at 90 DAS.
3. The dry matter accumulation of wheat increased significantly with all the organic and zinc sulphate treated plots as compared to T_1 (100% RDF) at all the growth stages. The maximum dry matter accumulation was observed under the treatment T_6 (100% RDF+2.5 t VC+20kg $ZnSO_4$ ha^{-1}).
4. The maximum number of effective shoots m^{-2} were recorded under the treatment T_6 (100% RDF+2.5 t VC+20kg $ZnSO_4$ ha^{-1}) which was significantly superior over T_1 (100% RDF).
5. The length of spike as well as no of grains spike^{-1} of wheat increased significantly with all the organic and zinc sulphate treated plots as compared to T_1 (100% RDF). The maximum length of spike was observed under the treatment T_6 (100% RDF+2.5 t VC+20kg ZnS_{O4}ha^{-1}) which was significantly superior over T_1 (100% RDF).
6. Various treatments did not affect the test weight of wheat significantly. However, the maximum value in respect to test weight was recorded under the treatment T_6 (100% RDF+2.5 t VC+20kg $ZnSO_4$ha^{-1}) followed by T_5 (100% RDF+5 t FYM+20kg $ZnSO_4$ha^{-1}).
7. The yield of grain and straw was higher with vermicompost plus zinc sulphate followed by FYM plus zinc sulphate than recommended dose of chemical fertilizer. The treatment T_6 (100% RDF+2.5 t VC+20kg $ZnSO_4$ha^{-1}) produced highest grain and straw yield which was significantly superior over T_1 (100% RDF).
8. The maximum value in respect to harvest index was recorded under the treatment T_6 (100% RDF+2.5 t VC+20kg $ZnSO_4$ha^{-1}) while minimum in treatment T_7 (75% RDF).

Table 4: Effect of nutrient management modules on plant height (cm) at different stages of wheat crop

Treatment	30 DAS			60 DAS			90 DAS			At harvest		
	2019-20	202-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	17	17	17	46	47	46	79	80	80	82	83	83
T_2	17	18	17	49	49	49	84	84	84	87	88	88
T_3	18	18	18	50	50	50	85	87	86	89	90	90
T_4	18	18	18	51	51	51	87	88	88	90	92	91
T_5	18	18	18	53	54	54	92	93	92	96	97	96
T_6	18	18	18	54	55	55	93	95	94	97	98	97
T_7	17	17	17	44	46	45	75	75	75	78	82	80
T_8	17	17	17	45	46	45	76	76	76	80	83	81
T_9	17	17	17	46	47	46	78	80	79	81	83	82
T_{10}	17	17	17	47	48	47	81	82	82	84	85	85
T_{11}	18	18	18	51	52	52	88	89	89	92	93	92
T_{12}	18	18	18	52	53	52	89	90	90	93	94	93
T_{13}	18	18	18	47	47	47	80	81	81	83	84	84
T_{14}	18	19	18	49	50	49	84	85	85	88	89	88
S.Em±	0.72	0.73	0.51	2.26	2.03	1.52	3.88	3.47	2.60	4.04	3.63	2.71
C.D. at 5%	NS	NS	NS	6.57	5.90	4.31	11.28	10.09	7.39	11.74	10.54	7.70

T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20kg $ZnSO_4$ ha^{-1}, T_3: RDF + 5 t FYM ha^{-1}, T_4: RDF + 2.5 t VC ha^{-1}, T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF(112.50:50:45 kg ha^{-1}), T_8: 75% RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75% RDF + 10 t FYM ha^{-1}, T_{10}: 75% RDF + 5 t VC ha^{-1}, T_{11}: 75% RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75% RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125% RDF (187.50:75:50 kg ha^{-1}), T_{14}: 125% RDF + 20 kg $ZnSO_4$ ha^{-1}

Table 2: Effect of nutrient management modules on chlorophyll content in leaves (mg g^{-1} fresh weight) at different stages of wheat crop

Treatment	30 DAS			60 DAS			90 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	1.62	1.64	1.63	2.59	2.63	2.61	1.59	1.61	1.60
T_2	1.68	1.70	1.69	2.75	2.79	2.77	1.61	1.63	1.62
T_3	1.72	1.74	1.73	2.87	2.91	2.89	1.62	1.64	1.63
T_4	1.74	1.76	1.75	2.93	2.97	2.95	1.63	1.65	1.64
T_5	1.82	1.84	1.83	3.11	3.15	3.13	1.66	1.68	1.67
T_6	1.85	1.87	1.86	3.18	3.22	3.20	1.67	1.69	1.68
T_7	1.48	1.55	1.52	2.43	2.55	2.49	1.30	1.37	1.33
T_8	1.57	1.63	1.60	2.48	2.58	2.53	1.48	1.54	1.51
T_9	1.60	1.62	1.61	2.55	2.58	2.56	1.57	1.59	1.58
T_{10}	1.66	1.68	1.67	2.71	2.74	2.72	1.61	1.63	1.62
T_{11}	1.76	1.78	1.77	3.00	3.04	3.02	1.64	1.66	1.65
T_{12}	1.79	1.81	1.80	3.05	3.09	3.07	1.65	1.67	1.66
T_{13}	1.65	1.67	1.66	2.64	2.67	2.66	1.61	1.63	1.62
T_{14}	1.70	1.72	1.71	2.82	2.86	2.84	1.62	1.64	1.63
S.Em±	0.07	0.07	0.05	0.11	0.12	0.08	0.07	0.07	0.05
C.D. at 5%	0.21	0.20	0.14	0.33	0.34	0.23	0.19	0.19	0.13

T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20kg $ZnSO_4$ ha^{-1}, T_3: RDF + 5 t FYM ha^{-1}, T_4: RDF + 2.5 t VC ha^{-1}, T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF(112.50:50:45 kg ha^{-1}), T_8: 75% RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75% RDF + 10 t FYM ha^{-1}, T_{10}: 75% RDF + 5 t VC ha^{-1}, T_{11}: 75% RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75% RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125% RDF(187.50:75:50 kg ha^{-1}), T_{14}: 125% RDF+ 20 kg $ZnSO_4$ ha^{-1}.

Table 3: Effect of nutrient management modules on dry matter accumulation (g m^{-2}) at different stages of wheat crop

Treatments	30 DAS			60 DAS			90 DAS		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	102	103	102	331	336	333	544	551	548
T_2	107	109	108	348	353	351	575	582	579
T_3	110	111	110	358	362	360	587	595	591
T_4	111	113	112	362	367	365	597	604	600
T_5	118	119	119	374	379	377	631	639	635
T_6	119	121	120	383	388	385	639	647	643
T_7	96	101	98	299	314	306	513	539	526
T_8	98	102	100	319	332	325	525	546	536
T_9	101	102	102	326	330	328	541	548	545
T_{10}	104	105	105	341	346	344	556	564	560
T_{11}	113	115	114	369	374	372	606	614	610
T_{12}	114	116	115	374	378	376	612	620	616
T_{13}	103	104	103	339	343	341	550	557	554
T_{14}	108	109	109	353	358	356	578	585	582
S.Em±	4.40	4.47	3.14	16.27	14.53	10.21	23.57	29.94	16.80
C.D. at 5%	12.80	12.99	8.90	47.28	42.25	28.98	68.52	69.57	47.67

T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20kg $ZnSO_4$ ha^{-1}, T_3: RDF + 5 t FYM ha^{-1}, T_4: RDF + 2.5 t VC ha^{-1}, T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF(112.50:50:45 kg ha^{-1}), T_8: 75% RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75% RDF + 10 t FYM ha^{-1}, T_{10}: 75% RDF + 5 t VC ha^{-1}, T_{11}: 75% RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75% RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125% RDF (187.50:75:50 kg ha^{-1}), T_{14}: 125% RDF + 20 kg $ZnSO_4$ ha^{-1}.

Table 4: Effect of nutrient management modules on effective shoot (m^{-2}), length of spike, no. of grains $spike^{-1}$ and test weight of wheat crop

Treatments	Effective shoots m^{-2}			Length of spike (cm)			No. of grains spike-1			Test weight (g)		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	357.72	362.37	360.05	12.73	12.90	12.81	41.66	42.20	41.93	38.40	38.90	38.65
T_2	378.05	382.96	380.50	13.45	13.62	13.54	44.33	44.91	44.62	39.12	39.63	39.37
T_3	386.18	391.20	388.69	13.89	14.07	13.98	46.00	46.60	46.30	39.40	39.91	39.66
T_4	392.27	397.37	394.82	14.21	14.39	14.30	48.33	48.96	48.64	39.64	40.16	39.90
T_5	414.63	420.02	417.33	14.95	15.14	15.05	51.00	51.66	51.33	40.56	41.09	40.82
T_6	420.32	425.79	423.05	15.24	15.44	15.34	52.33	53.01	52.67	41.72	42.26	41.99
T_7	337.40	354.26	345.83	12.05	12.65	12.35	38.66	40.59	39.63	36.82	38.66	37.74
T_8	345.53	359.35	352.44	12.28	12.77	12.53	39.00	40.56	39.78	37.58	39.08	38.33
T_9	353.66	360.64	357.15	12.51	12.67	12.59	40.66	41.19	40.92	38.24	38.74	38.49
T_{10}	365.85	370.61	368.23	13.22	13.39	13.31	43.00	43.56	43.28	39.05	39.56	39.30
T_{11}	398.37	403.55	400.96	14.45	14.64	14.54	49.66	50.31	49.98	39.82	40.34	40.08
T_{12}	402.44	407.67	405.05	14.68	14.87	14.78	50.33	50.98	50.66	40.31	40.83	40.57
T_{13}	361.79	366.49	364.14	12.94	13.20	13.07	42.33	43.17	42.75	38.76	39.53	39.14
T_{14}	80.08	385.02	382.55	13.67	13.85	13.76	45.00	45.59	45.29	39.30	39.81	39.56
S.Em±	17.54	15.74	11.78	0.64	0.57	0.43	2.12	1.89	1.42	1.84	1.62	1.23
C.D. at 5%	50.98	45.75	33.44	1.85	1.65	1.21	6.16	5.51	4.03	NS	NS	NS

T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20kg $ZnSO_4$ ha^{-1}, T_3: RDF + 5 t FYM ha^{-1}, T_4: RDF + 2.5 t VC ha^{-1}, T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF(112.50:50:45 kg ha^{-1}), T_8: 75% RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75% RDF + 10 t FYM ha^{-1}, T_{10}: 75% RDF + 5 t VC ha^{-1}, T_{11}: 75% RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75% RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125% RDF(187.50:75:50 kg ha^{-1}), T_{14}: 125% RDF + 20 kg $ZnSO_4$ ha^{-1}.

Table 5: Effect of nutrient management modules on grain, straw yield and harvest index of wheat crop

Treatments	Yield (q ha^{-1}) Grain			Straw			Harvest Index (%)		
	2019-20	202-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1.	41.51	42.05	41.78	62.26	63.07	62.67	39.97	40.00	39.99
T_2	42.45	43.00	42.73	65.80	66.66	66.23	39.29	39.22	39.26
T_3	44.81	45.39	45.10	66.74	67.60	67.17	40.14	40.17	40.15
T_4	45.52	46.11	45.81	67.77	68.65	68.21	40.17	40.18	40.17
T_5	47.74	48.36	48.05	68.83	69.73	69.28	41.02	40.95	40.99
T_6	50.47	51.13	50.80	70.61	71.53	71.07	41.66	41.68	41.67
T_7	35.38	35.84	35.61	56.60	57.34	56.97	38.43	38.46	38.44
T_8	35.99	36.46	36.22	57.59	58.33	57.96	38.46	38.46	38.46
T_9	36.56	37.28	36.92	58.88	59.65	59.26	38.19	38.46	38.33
T_{10}	42.08	42.62	42.35	63.68	64.51	64.09	39.88	39.79	39.83
T_{11}	46.23	46.83	46.53	66.87	67.74	67.31	40.89	40.87	40.88
T_{12}	47.64	48.26	47.95	67.80	68.68	68.24	41.26	41.27	41.26
T_{13}	41.79	42.34	42.06	63.25	64.08	63.67	39.86	39.78	39.82
T_{14}	44.10	44.68	44.39	66.16	67.02	66.59	39.95	40.00	39.97
S.Em±	1.98	1.80	1.34	2.65	2.69	1.89			
C.D. at 5%	5.76	5.23	3.79	7.71	7.81	5.35			

T_1: RDF (150:60:40 kg ha^{-1} NPK), T_2: RDF + 20kg $ZnSO_4$ ha^{-1}, T_3: RDF + 5 t FYM ha^{-1}, T_4: RDF + 2.5 t VC ha^{-1}, T_5: RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_6: RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}, T_7: 75% RDF(112.50:50:45 kg ha^{-1}), T_8: 75% RDF +20kg $ZnSO_4$ ha^{-1}, T_9: 75% RDF + 10 t FYM ha^{-1}, T_{10}: 75% RDF + 5 t VC ha^{-1}, T_{11}: 75% RDF +10 t FYM + 20 kg $ZnSO_4$ ha^{-1}, T_{12}: 75% RDF + 5 t VC +20 kg $ZnSO_4$ ha^{-1}, T_{13}: 125% RDF(187.50:75:50 kg ha^{-1}), T_{14}: 125% RDF + 20 kg $ZnSO_4$ ha^{-1}.

Conclusion

1. Maximum growth, yield attributes and yield of wheat crop were recorded under the nutrient management module T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}) closely followed by T_5 (100% RDF+5 t FYM+20 kg $ZnSO_4$ ha^{-1}). Significantly higher grain and straw yield were recorded under treatment having T_6 (100% RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) over T_1 (100% RDF). The significant differences were found in case of protein content also. The highest value of pooled protein content was recorded in treatment T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}).
2. Organic carbon content of soil increased in all the treatments consisting FYM or vermicompost in combination with inorganic fertilizers over inorganic fertilizers alone. Maximum organic carbon content of soil was observed under treatment T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}).Maximum reduction of pH and EC was observed under treatment T_{11} having 75% RDF + 10 t FYM+ 20 kg $ZnSO_4$ ha^{-1}. However, differences in pH and EC were found non-significant. Tremendous improvement in available N, P, K, S and Zn contents of soil after harvest stage were estimated under the plots having T_6 (100% RDF +2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) closely followed by T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4$ ha^{-1}).
3. The maximum N, P, K, S and Zn uptake were noticed under the treatment T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}) followed by treatment T_5 (100% RDF + 5 t FYM+20 kg $ZnSO_4$ ha^{-1}).
4. The higher net return (₹ 68538ha^{-1}) and benefit cost ratio (2.71) were in treatment T_6 (100% RDF+2.5 t VC+20 kg $ZnSO_4$ ha^{-1}) closely followed by treatment T_5 (100% RDF+5 t FYM+20 kg $ZnSO_4$ ha^{-1}).

On the basis of results summarized above, it may be concluded that nutrient management module 100% RDF+2.5 t VC+20 kg ZnSO4 ha-1 proved best for improving nutrient uptake, yield attributes and yield of wheat as well as soil properties. Also the highest net return was recorded in the same treatment. Therefore, the nutrient management module 100% RDF+2.5 t VC+20 kg ZnSO4 ha-1 may safely be recommended for growing of wheat in eastern part of Rajasthan.

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