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Research on effects of various nutrient management modules on nutrient uptake and productivity of wheat crop

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Abstract
The research work aimed to investigate the effect of various nutrient management modules on growth and yield of wheat crop. Was carried out during two consecutive *rabi* seasons of 2019-20 and 2020-21 The experiment was laid on randomized block design with 14 treatments, i.e., Control (T1)N, P_2O_5 and K_2O *i.e.*, @ 150, 60 and 40 kg ha^{-1}, 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 + 20 kg $ZnSO_4$ 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 treatments consisting different combinations of organic (vermicompost and FYM) and inorganic (RDF and $ZnSO_4$) fertilizers were being tested in Randomized Block Design with three replications to examine the impact of nutrient management modules having chemical fertilizers alone and their combination with organic sources on productivity, nutrient uptake and soil properties taking wheat as test crop. 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}). 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}). Most of the growth and yield related parameters of wheat crop was found significantly maximum in treatment T_6. Nutrient analysis and its uptake in wheat under the effect of nutrient management module is also explored and presented in this research work.

Keywords: Sulphur and zinc, nutrient uptake, wheat crop

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops in the world. Globally, it ranks next to rice (Das *et al*., 2019) [9]. It is used in various forms by more than one billion in the world. Not only human beings even large population of the cattle feeds on wheat straw. Nutritionally it is important source of protein including "gluten" which provides the frame work for sponge cellular texture of bread and baked products, vitamins like niacin and thiamin. 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 tonnes) (Singh *et al*., 2021) [10]. 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 tones ha^{-1} (Ramadas *et al*, 2019) [11]. The challenge for agriculture over the coming decades will be to meet the world's increasing demand for food in a sustainable way. Declining soil fertility and mismanagement of plant nutrient have made this task more difficult to complete vision 2020. Integrated nutrient management approach to the management of plant nutrient for maintaining and enhancing soil fertility, where both natural and manmade sources of plant nutrients are used, can provide the food need of world population (projected to exceed 7.5 billion by the year 2020). In recent years, concept of Integrated Nutrient Supply involving combined use of organic sources and chemical fertilizers has been developed.

The use of adequate dose of organic sources coupled with chemical fertilizers is expected to ensure optimum growth condition under intensive pattern of farming using high yielding varieties. Among all essential nutrient's nitrogen, phosphorus, potash and zinc are the most important for the plants and also most limiting nutrients in Indian soils due to less and imbalance application. So, application of N, P, K and Zn containing fertilizers in proper proportion is necessary to augment the productivity of wheat. Since organic manures are known to improve the soil health, water retention and supply of most of the nutrients, hence the use of these in the form of Farm Yard Manure and vermicompost will certainly boost up crop production. Tulsa Ram *et al*. (2006) [4].

Materials and Methods

Research was carried out during two consecutive *Rabi* seasons of 2019-20 and 2020-21 at Instructional Farm of Bhagwant University, Ajmer, Rajasthan. The experimental site located at Ajmer is situated 10 km away from Ajmer city on Sikar Road. The experiment was laid on randomized block design with 14 treatments, i.e., Control (T1)N, P_2O_5 and K_2O *i.e.*, @ 150, 60 and 40 kg ha^{-1}, 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}.and Farm yard manure and Vermicompost as per treatment were incorporated uniformly in the plots before 15 days of sowing of wheat.

Fertilizer application

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 muriate of potash, respectively as per treatment. Rather *et al. (*2009) [7]

Results and Discussion

Sulphur content in grain

The pooled data on sulphur content in grain as influenced by various nutrient management treatments have been presented in Table 4.1 & 4.2. It clearly indicates that the maximum sulphur content in grain (0.20%) was recorded with the application of T_6 (100% RDF + 2.5 t VC+20kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_3 (100% RDF + 5 t FYM ha^{-1}), T_4 (100% RDF + 2.5 t VC ha^{-1}), T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4ha^{-1}$), T_{11} (75% RDF + 10 t FYM + 20 kg $ZnSO_4ha^{-1}$) and T_{12} (75% RDF + 5 t VC + 20 kg $ZnSO_4ha^{-1}$) and significantly superior over rest of the treatments. The minimum sulphur content in grain (0.16 kg ha^{-1}) was recorded under T_7 (75% RDF).

Sulphur content in straw

The pooled data on sulphur content in straw as influenced by various treatments have been presented in Table 4.1 & 4.2. It clearly indicates that the maximum sulphur content in straw (0.12%) was recorded with the application of T_6 (100% RDF + 2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_4 (100% RDF + 2.5 t VC ha^{-1}), T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4ha^{-1}$), T_{11} (75% RDF + 10 t FYM + 20 kg $ZnSO_4ha^{-1}$), T_{12} (75% RDF + 5 t VC + 20 kg $ZnSO_4ha^{-1}$) and T_{14} (125% RDF + 20 kg $ZnSO_4ha^{-1}$) and significantly superior over rest of the treatments. The minimum sulphur content in straw (0.09 kg ha^{-1}) was recorded under T_7 (75% RDF).

Sulphur uptake by grain

The pooled data on sulphur uptake by grain as influenced by various nutrient management modules have been presented in Table - 4.1 & 4.2. It clearly indicates that the maximum sulphur uptake by grain (10.20 kg ha^{-1}) was recorded with the application of T_6 (100% RDF + 2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4ha^{-1}$) and T_{12} (75% RDF + 5 t VC+20 kg $ZnSO_4ha^{-1}$) and significantly superior over rest of the treatments. The minimum sulphur uptake by grain (5.71 kg ha^{-1}) was recorded under T_7 (75% RDF).

Sulphur uptake by straw

The pooled data on sulphur uptake by straw as influenced by various treatments have been presented in Table -4.1 & 4.2. It clearly indicates that the maximum sulphur uptake by straw (8.30 kg ha^{-1}) was recorded with the application of treatment T_6 (100% RDF + 2.5 t VC+20kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_3 (100% RDF + 5 t FYM ha^{-1}), T_4 (100% RDF + 2.5 t VC ha^{-1}), T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4ha^{-1}$), T_{11} (75% RDF + 10 t FYM+20 kg $ZnSO_4ha^{-1}$), T_{12} (75% RDF + 5 t VC + 20 kg $ZnSO_4ha^{-1}$) and T_{14} (125% RDF + 20 kg $ZnSO_4ha^{-1}$) and significantly superior over rest of the treatments. The minimum sulphur uptake by straw (5.84 kg ha^{-1}) was recorded under T_7 (75% RDF).

Zinc content in grain

The Pooled data on zinc content in grain as influenced by various treatments have been presented in Table 4.1 & 4.2. It clearly indicated that the maximum zinc content in grain (40.14 mg kg^{-1}) was recorded with the application of T_6 (100% RDF + 2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_4 (100% RDF + 2.5 t VC ha^{-1}), T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4ha^{-1}$), T_{11} (75% RDF + 10 t FYM + 20 kg $ZnSO_4ha^{-1}$) and T_{12} (75% RDF + 5 t VC + 20 kg $ZnSO_4ha^{-1}$) and significantly superior over rest of the treatments. The minimum zinc content in grain (32.22 mg kg^{-1}) was recorded under T_7 (75% RDF).

Zinc content in straw

Pooled data regarding zinc content in straw as influenced by various treatments have been presented in Table 4.1 & 4.2. It clearly indicates that the maximum zinc content in straw (20.81 mg kg^{-1}) was recorded with the application of treatment T_6 (100% RDF + 2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_4 (100% RDF + 2.5 t VC ha^{-1}), T_5 (100% RDF + 5 t FYM+20 kg $ZnSO_4ha^{-1}$), T_{11} (75% RDF + 10 t FYM + 20 kg $ZnSO_4ha^{-1}$) and T_{12} (75% RDF + 5 t VC + 20 kg $ZnSO_4ha^{-1}$) and significantly superior over rest of the treatments. The minimum zinc content in straw (16.71 mg kg^{-1}) was recorded under T_7 (75% RDF).

Zinc uptake by grain

The pooled data presented on zinc uptake by grain as influenced by various treatments have been presented in Table 4.1 & 4.2. It clearly indicated that the maximum zinc uptake by grain (204.94 g ha^{-1}) was recorded with the application of treatment T_6 (100% RDF + 2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4$ha^{-1}) and T_{12} (75% RDF + 5 t VC + 20 kg $ZnSO_4$ha^{-1}) and significantly superior over rest of the treatments. The minimum zinc uptake by grain (114.77 mg kg^{-1}) was recorded under T_7 (75% RDF). Patra *et al.* (1999) [8]

Zinc uptake by straw

The perusal of pooled data on zinc uptake by straw as influenced by various treatments have been presented in table 4.1&4.2. It clearly indicates that the maximum zinc uptake by straw (148.13 g ha^{-1}) was recorded with the application of treatment T_6 (100% RDF + 2.5 t VC + 20 kg $ZnSO_4$ ha^{-1}) which was statistically at par with T_3 (100% RDF + 5 t FYM ha^{-1}), T_4 (100% RDF + 2.5 t VC ha^{-1}), T_5 (100% RDF + 5 t FYM + 20 kg $ZnSO_4$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}) and T_{14} (125% RDF + 20 kg $ZnSO_4$ha^{-1}) and significantly superior over rest of the treatments. The minimum zinc uptake by straw (104.36 g ha^{-1}) was recorded under T_7 (75%RDF). Patra *et al.* (1999) [8]

Table 1: Effect of nutrient management modules on sulphur content and uptake by grain and straw of wheat crop

Treatments	S content (%)						S uptake (kg ha^{-1})					
	Grain			Straw			Grain			Straw		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	0.17	0.17	0.17	0.10	0.10	0.10	7.02	7.21	7.11	6.40	6.57	6.49
T_2	0.18	0.18	0.18	0.10	0.10	0.10	7.84	8.09	7.97	6.71	6.89	6.80
T_3	0.18	0.19	0.18	0.11	0.11	0.11	8.18	8.40	8.29	7.14	7.33	7.24
T_4	0.19	0.19	0.19	0.11	0.11	0.11	8.44	8.66	8.55	7.32	7.52	7.42
T_5	0.20	0.20	0.20	0.11	0.12	0.12	9.33	9.64	9.48	8.00	8.21	8.11
T_6	0.20	0.20	0.20	0.12	0.12	0.12	10.07	10.33	10.20	8.19	8.40	8.30
T_7	0.16	0.16	0.16	0.09	0.09	0.09	5.63	5.79	5.71	5.77	5.92	5.84
T_8	0.16	0.17	0.16	0.09	0.10	0.10	5.89	6.04	5.96	5.96	6.12	6.04
T_9	0.17	0.17	0.17	0.10	0.10	0.10	6.17	6.36	6.27	6.26	6.43	6.35
T_{10}	0.17	0.18	0.17	0.10	0.10	0.10	7.32	7.58	7.45	6.66	6.84	6.75
T_{11}	0.19	0.19	0.19	0.11	0.11	0.11	8.70	8.94	8.82	7.47	7.67	7.57
T_{12}	0.19	0.19	0.19	0.11	0.11	0.11	9.06	9.30	9.18	7.70	7.90	7.80
T_{13}	0.17	0.17	0.17	0.11	0.11	0.11	7.21	7.43	7.32	6.87	7.05	6.96
T_{14}	0.18	0.18	0.18	0.11	0.11	0.11	7.95	8.17	8.06	7.12	7.31	7.22
S.Em±	0.008	0.007	0.006	0.004	0.004	0.003	0.55	0.66	0.43	0.57	0.59	0.41
C.D. at 5%	0.024	0.022	0.016	0.012	0.013	0.009	1.60	1.93	1.22	1.66	1.70	1.16

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 zinc content and uptake by grain and straw of wheat crop

Treatments	Zn content (mg kg^{-1})						Zn uptake (g ha^{-1})					
	Grain			Straw			Grain			Straw		
	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled	2019-20	2020-21	Pooled
T_1	34.33	34.77	34.55	17.80	18.03	17.92	142.54	146.46	144.50	114.33	117.32	115.82
T_2	34.71	35.16	34.94	18.00	18.23	18.12	147.48	152.26	149.87	119.89	123.02	121.45
T_3	36.64	37.12	36.88	19.00	19.25	19.12	164.36	168.71	166.53	127.55	130.89	129.22
T_4	37.22	37.70	37.46	19.30	19.55	19.43	169.48	173.90	171.69	130.80	134.22	132.51
T_5	39.34	39.85	39.60	20.40	20.67	20.53	187.33	193.68	190.50	142.87	146.61	144.74
T_6	39.88	40.40	40.14	20.68	20.95	20.81	202.28	207.60	204.94	146.22	150.04	148.13
T_7	32.01	32.43	32.22	16.60	16.82	16.71	113.12	116.41	114.77	103.01	105.71	104.36
T_8	32.40	32.82	32.61	16.80	17.02	16.91	116.85	119.90	118.38	106.48	109.27	107.87
T_9	33.56	34.22	34.00	17.52	17.74	17.63	124.01	127.78	125.90	111.84	114.77	113.31
T_{10}	34.71	35.16	34.94	18.00	18.23	18.12	145.79	150.91	148.35	118.95	122.06	120.50
T_{11}	37.80	38.29	38.04	19.60	19.85	19.73	174.82	179.53	177.18	133.43	136.92	135.17
T_{12}	38.18	38.68	38.43	19.80	20.06	19.93	181.98	186.73	184.35	137.46	141.05	139.25
T_{13}	36.64	37.12	36.88	19.00	19.25	19.12	153.13	157.93	155.53	122.62	125.83	124.22
T_{14}	36.80	37.27	37.03	19.08	19.33	19.20	163.00	167.37	165.19	127.21	130.54	128.88
S.Em±	1.48	1.50	1.05	0.77	0.78	0.55	11.06	13.34	8.66	10.19	10.46	7.30
C.D. at 5%	4.30	4.36	2.98	2.23	2.26	1.54	32.14	38.78	24.98	29.63	30.41	20.72

Effects of various nutrient management modules on nutrient uptake

Various nutrient management modules influenced the sulphur content in grain and straw of wheat. The maximum sulphur content in grain and straw was recorded with the application of T_6 (100% RDF +2.5 t VC + 20 kg ZnSO4ha^{-1}) followed by T_5 (100% RDF + 5 t FYM + 20 kg ZnSO4ha^{-1}) which were significantly superior over T_7 (75% RDF). Slight increase in sulphur concentration with application of vermicompost, FYM and ZnSO4may be attributed to the additional supply of this element by conversion of organic form of nutrient to inorganic form as well as improved physical condition of soil resulted increase in S concentration of plant. Similar findings were also observed by Sharma *et al.* (2013) [1] and Singh *et al*. (2011) [5]

Various nutrient management modules affected the zinc content in grain and straw of wheat. The maximum zinc content in grain and straw of wheat was found with T_6 (100% RDF + 2.5 t VC + 20 kg ZnSO4ha^{-1}) followed by T_5 (100% RDF + 5 t FYM + 20 kg ZnSO4ha^{-1}) which were significantly superior over T_7 (75% RDF). The increase in Zn content under treatment having ZnSO4, vermicompost and FYM treated plots might be due to chelating effect and improved native as well as added Zn in soil at all the growth stages. These results closely related to the findings of Keram *et al.* (2012) [2] and Sharma *et al*. (2013) [1].

Uptake of nutrients by the plant

The various nutrient management modules also affected the S and Zn uptake by the crop. Highest S and Zn uptake noticed in treatment receiving T_6 (100% RDF + 2.5 t VC + 20 kg ZnSO4ha-^{1}). Application of vermicompost and FYM along with 100% and 75% RDF increased the S uptake significantly over 100% and 75% RDF alone. The increase in uptake by the crop of wheat might be because of increase in their content in grain and straw as well as total biological yield and concentration of nutrients. Further, it is evident that maximum Zn uptake was recorded under treatment T_6 (100% RDF + 2.5 t VC + 20 kg ZnSO4ha^{-1}). Application of vermicompost and FYM along with 100% and 75% RDF increased the Zn uptake significantly over 100% and 75% RDF alone treatments. Sharma *et al*. (2005) [6]. Increased uptake of zinc by wheat crop with application of organic manures and increase in NPK doses may be attributed to the adequate supply of this nutrient, its content in grain and straw and total biomass. Similar findings have been reported by Keram *et al*. (2012) [2] and Sharma *et al.* (2013) [1].

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