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Estimation of soil fertility status in wheat cultivated areas under different nutrient management practices

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Abstract
A field experiment was conducted during *rabi* season of 2020-21 on loamy sand soils of Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to assess the impact of vermicompost, bio fertilizer and nitrogen levels on growth, yield and economics of wheat. Wheat (*Triticum aestivum* L.) is king of cereals and one of the most important staple food crops. Wheat belongs to *Gramineae* family and second important food grain crop of India being next to rice. This crop is mainly responsible for the green revolution and mitigating the problem of food insecurity in India. An adequate supply of nitrogen is associated with vegetative growth and maintains genetical material, while its deficit results in yellowing and stunted plant growth thereby, adversely affecting quantity and quality of crop produce. The soil was low in organic carbon (0.22%) and available nitrogen (165.8 kg/ha), medium in available phosphorus (43.8 kg/ha) and high in potash (330.9 kg/ha).Combined application of 4 t/ha vermicompost + 100% RDN produced significantly higher grain yield (5096 kg/ha) and straw yield (6362 kg/ha) over other combination but being at par with treatment combination 4 t/ha vermicompost + 75% RDN. Total N, P and K uptake as well as available N, P_2O_5 and K_2O after harvest were found the highest with higher level of inputs *i.e.*, vermicompost, bio fertilizer and nitrogen. The maximum net realization ₹ 58272/ha was secured with application of 2 t/ha vermicompost along with 100% RDN and bio fertilizer inoculation.

Keywords: Wheat, soil fertility, vermicompost, bio fertilizer and nitrogen

Introduction
Wheat (*Triticum aestivum* L.) is king of cereals and one of the most important staple food crops. Wheat belongs to *Gramineae* family and second important food grain crop of India being next to rice. This crop is mainly responsible for the green revolution and mitigating the problem of food insecurity in India. About 35 percent of the world's population directly or indirectly depends upon wheat for food and providing 20 percent of human dietary and serving as the main source of protein in developing nations. The nutritive value of wheat is fairly high as compared to other cereals. It contains protein (11.80%), fat (1.50%), carbohydrates (71.20%), mineral matter (1.50%), calcium (0.50%) and phosphorus (0.32%) (Swaminathan *et al*., 1981) [11]. It is a global crop having an area of about 216.66 million hectares and 764.41 million metric tonnes production in world during 2019-20. (Anon., 2020a) [2]. The major wheat growing countries in the world are China, India, Russia, USA, France, Australia, Canada, Pakistan, Ukraine and Germany. It is an important winter cereal contributing about 38% of the total food grain production in India. Wheat straw is an important source of fodder for a large animal population in India.

The recycling of waste through earthworms is called vermiculture technology or vermicomposting. Vermicompost is a rich source of different essential nutrients which improve overall soil condition and promote yield and growth of plant (Pezeshkpour *et al*., 2014) [10]. On an average vermicompost contains nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25% (Sinha, 2009). Vermicompost contains different types of soil beneficial microbes that can improve plant growth through vitamins, hormones and antibodies (Lourduraj, 2006) [6]. Vermicompost also contains different enzymes which are responsible for degradation of large organic molecules for enhancement of further microbial activity (Gupta, 2003) [4]. It is also advantageous in preventing leaching of nutrients and even in conserving nutrients, bacterial, valuable enzymes and vitamins in soil.

Nitrogen is important mineral nutrients for plants influencing growth, development, yield and protein content of grains.

It promotes shoot elongation, tillering and regeneration after defoliation and governs to considerable degree. Nitrogen is the most limiting factor for high crop productivity but its use efficiency is low. Secondly, the application of increased doses of N increases cost of production. Wheat is sensitive to nitrogen deficiency and very responsive to nitrogen fertilization. Thus, there is a need to economise the nitrogen dose but nitrogen requirement depends on the type of soil, climate, production practices, available moisture and cropping pattern. It is reported that 50 quintals of wheat grain per hectare can be secured with application of 100-150 kg nitrogen, 70-80 kg phosphorus and 125-150 kg potash (Mishra, 1979) [8]. Nitrogen management is important in improving quality and productivity of wheat (Patel *et al.*, 2004) [9]. An adequate supply of nitrogen is associated with vegetative growth and maintains genetical material, while its deficit results in yellowing and stunted plant growth thereby, adversely affecting quantity and quality of crop produce. On the other hand, excess application of nitrogen is not only escalating the cost of cultivation but lead to the pest-disease incidence and growth of weeds.

Material and Methods

The field experiment was laid out during *rabi* season of the 2020-21 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, District: Banaskantha (Gujarat) is situated at 24^o 19' North latitude and 72^o 19' East longitude with an elevation of 154.52 meters above the mean sea level and situated in the North Gujarat Agro-climatic Region. The soil of the experimental plot was loamy sand in texture low in organic carbon, available nitrogen, medium in available phosphorus and high potassium status. Experiment carried out with total twelve treatment combinations consisting three levels of vermicompost *viz.* V_1: No vermicompost, V_2: 2 t/ha, V_3: 4 t/ha and two levels of bio fertilizer *viz.* B_1: No bio fertilizer, B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed and two levels of nitrogen *viz.* N_1: 75% RDN, N_2: 100% RDN were embedded.

The experiment was laid out in factorial randomized block design with three replications. Dates of all operations were noted; data collected including growth parameters *viz.* plant height, Number of tillers per plant, Dry matter accumulation, Crop growth rate (CGR), Relative growth rate (RGR),length of spike (cm), number of seed per spike (g), grain weight/spike (g), test weight (g), grain yield (kg/ha), straw yield (kg/ha) and harvest index (%). For the height of main shoot, random selection of five representative plants from each net plot was done and their height measured from ground level to the tip of plant, the mean was recorded. For recording dry matter, plants of 50 cm row length were cut close to the ground from two places in boarder row on either side in each plot at 30, 60 and at harvest. The plants were first sun dried and then dried in oven at 65±2 °C for 3-4 days till a constant weight was obtained at each stage. After drying, samples were weighed and the value of dry matter accumulation per metre row length was calculated. The significance of difference was tested by "F" test at 5 percent level. The critical difference was calculated when the differences among treatments were found significant under "F" test. In remaining cases only standard error of mean was worked out.

Plant analysis

(a) Nutrient content (% NPK)

For estimation of nitrogen, phosphorus and potassium content in grain and straw representative samples were drawn from the produce of each net plot. The samples were oven dried at 60 °C for 24 hours, powdered by mechanical grinder and nutrients were estimated by using methods

(b) Nutrient uptake (NPK)

The following formula was used for calculation of uptake of nutrients

$$\text{Nutrient uptake (kg/ha)} = \frac{\left(\text{Content in seed (\%)} \times \text{Seed yield (kg/ha)}\right) + \left(\text{Content in straw (\%)} \times \text{Straw yield (kg/ha)}\right)}{100}$$

Initial composite soil sample was drawn from 0-15 cm soil depth before application of fertilizers and sowing of the crop from different spots of experimental site. Soil samples were also drawn (0-15 cm depth) from each plot of all the replications after the harvest of crop. The soil samples were air dried, powdered and then sieved through 2.0 mm mesh and used for analysis. All soil samples collected for chemical analysis were used to determine available nitrogen, available phosphorus and available potassium.

Results and Discussion

Effect on content and uptake of nutrients

Nitrogen content (%) in seed and straw

The data pertaining to the effect of vermicompost, bio fertilizer and nitrogen levels on nitrogen content (%) in seed and straw of wheat are presented in Table 1.

Effect of vermicompost

Data presented in Table 1revealed that application of vermicompost exerted their significant influence on nitrogen content in grain and straw of wheat. Treatment V_3 (4 t/ha vermicompost) recorded significantly the highest nitrogen content in grain and straw (1.71 and 0.70%, respectively).

This might be due to higher levels of vermicompost which have more nitrogen content and also have more microrganism which convert unavailable nitrogen to available nitrogen leading higher N contain in grain and straw. Similar results were also reported by Hussain *et al*. (2018) [5] and Fazily *et al*. (2020) [3].

Effect of bio fertilizer

A perusal of data presented in Table 1 revealed that seed inoculation with bio fertilizer (*Azotobacterchroococcum*) exerted their non-significant influence on nitrogen content in grain and straw of wheat. Seed inoculation with *Azotobacter chroococcum* @ 5 ml/kg of seed recorded numerically the maximum nitrogen content in grain and straw (1.64 and 0.67%, respectively).

Effect of nitrogen levels

Different nitrogen levels showed their significant influence on nitrogen content in grain and straw of wheat which are presented in Table 1. An application of 100% RDN (N_2) recorded significantly the highest nitrogen content in grain and straw (1.65 and 0.68%, respectively), while the lowest nitrogen content in grain and straw (1.58 and 0.54%, respectively) were recorded under application of 75% RDN (N_1). The increase in nitrogen content with increase in nitrogen levels might be due to improved availability of soil nitrogen under this level.Similar results reported by Mattas *et al.* (2011) [7] and Alam (2013) [1].

Phosphorus content in seed and straw

The data pertaining to the effect of vermicompost, bio fertilizer and nitrogen levels on phosphorus content in seed and straw of wheat are presented in Table 2.

Effect of vermicompost

A perusal of data presented in Table 2 revealed application of that vermicompost failed to exert their significant influence on phosphorus content in seed and straw of wheat. Treatment V_3 (4 t/ha vermicompost) recorded numerically the maximum phosphorus content in seed and straw (0.30 and 0.18%, respectively) as compared to treatment V_2 (2 t/ha vermicompost) and V_1 (no vermicompost). Lower values of phosphorus content in grain and straw (0.28 and 0.18%, respectively) were recorded in treatment V_1 (no vermicompost).

Effect of bio fertilizer

Seed inoculation of *Azotobacterchroococcum*@ 5 ml/kg of seed (treatment B_2) seed inoculation had non-significant effect on phosphorus contain in grain and straw. However, seed inoculation recorded maximum phosphorous content in garin and straw (0.30 and 0.18%, respectively).

Effect of nitrogen levels

Different nitrogen levels showed their non-significant influence on phosphorous content in grain and straw of wheat. An application of 100% RDN(N_2) recorded maximum phosphorous content in grain and straw (0.30 and 0.18%, respectively) while the lowest phosphorous content in grain and straw (0.29 and 0.18%, respectively) was recorded under application of 75% RDN (N_1).

Potassium content in seed and straw

The data pertaining to the effect of vermicompost, bio fertilizer and nitrogen levels on potassium content in seed and straw of wheat are presented in Table 3.

Effect of vermicompost

A perusal of data displayed in Table 3 indicates that various levels of vermicompost did not exert their significant effect on potassium content in grain and straw. While, treatment V_3 (4 t/ha vermicompost) recorded maximum potassium content (%) in grain and straw. The lowest potassium content was observed in grain and straw (0.38 and 0.97%) under treatment V_1 (no vermicompost).

Effect of bio fertilizer

Effect of *Azotobacter chroococcum* as bio fertilizer in respect to potassium content in seed and straw of wheat was found non-significant. However, seed inoculation of *Azotobacter chroococcum* @ 5 ml/kg of seed (B_2) recorded the maximum potassium content in grain and straw (0.39 and 0.99%, respectively).

Effect of nitrogen levels

An appraisal of data presented in Table 3 revealed that different nitrogen levels showed their non-significant influence on potassium content in grain and straw of wheat. While an application of 100% RDN (N_2) recorded maximum potassium content in grain and straw (0.38 and 0.99%, respectively), while the lowest phosphorous content in grain and straw (0.38 and 0.97%, respectively) was recorded under application of 75% RDN (N_1).

Effect on available N, P_2O_5 and K_2O after harvest

The data pertaining to the effect of vermicompost, bio fertilizer and nitrogen levels on available N, P_2O_5 and K_2O after harvest of wheat crop are presented in Table 4.

Effect of vermicompost

A perusal of data showed in Table 4revealed that various levels of vermicompost exert their significant influence on available N after harvest, while available of P_2O_5 and K_2O didn't affected significantly by various levels of vermicompost. Treatment V_3 (4 t/ha vermicompost) recorded significantly the highest available N (177.66 kg/ha) after harvest. Numerically the maximum value of P_2O_5 and K_2O 41.85 and 332.80 kg/ha recorded under V_3 (4 t/ha vermicompost).Whereas, minimum available N, P_2O_5 and K_2O after harvest159.71, 39.49 and 323.63 kg/ha were recorded under no vermicompost (V_1).

Effect of bio fertilizer

A perusal of data presented in Table 4 revealed that various levels of bio fertilizer did not exert their significant influence on available P_2O_5 and K_2Oafter harvest. While treatment B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed) recorded significantly the higher available N after harvest. Numerically maximum available N, P_2O_5 and K_2Oafter harvest (41.24 and 329.28 kg/ha) respectively under B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed) compared to no inoculation.

Effect of nitrogen

A perusal of data showed in Table 4 revealed that various levels of nitrogen did not exert their significant influence on available P_2O_5 and K_2Oafter harvest. Treatment N_2 (100% RDN) recorded significantly higher available N after harvest. Maximum available P_2O_5 and K_2O after harvest41.58 and 329.87 kg/ha recorded under 100% RDN treatment. Whereas, the lowest available N, P_2O_5 and K_2O after harvest165.07, 41, 39.86 and 326.51 kg/ha were recorded under 75% RDN.

Table 1: Effect of vermicompost, bio fertilizer and nitrogen levels on N content of grain and straw of wheat

Treatments		Nitrogen content (%)	
		Grain	Straw
A.	**Vermicompost levels**		
	V_1: No vermicompost	1.51	0.62
	V_2: 2 t/ha vermicompost	1.62	0.66
	V_3: 4 t/ha vermicompost	1.71	0.70
	S.Em. ±	0.02	0.01
	C.D. at 5%	0.06	0.03
B.	**Bio fertilizer levels**		
	B_1: No Bio fertilizer	1.59	0.65
	B_2: *Azotobacterchroococcum* inoculation @ 5 ml/kg seed	1.64	0.67
	S.Em. ±	0.02	0.01
	C.D. at 5%	NS	NS
C.	**Nitrogen levels**		
	N_1: 75% RDN	1.58	0.54
	N_2: 100% RDN	1.65	0.68
	S.Em. ±	0.02	0.01
	C.D. at 5%	0.05	0.02
Interactions			
V × B		NS	NS
V × N		Sig.	Sig.
B× N		NS	NS
V × B × N		NS	NS
C.V.%		4.58	5.21

Table 2: Effect of vermicompost, bio fertilizer and nitrogen levels on phosphorus content of grain and straw of wheat

Treatments		Phosphorus content	
		Grain	Straw
A.	**Vermicompost levels**		
	V_1: No vermicompost	0.28	0.18
	V_2: 2 t/ha vermicompost	0.29	0.18
	V_3: 4 t/ha vermicompost	0.30	0.18
	S.Em. ±	0.001	0.00
	C.D. at 5%	NS	NS
B.	**Bio fertilizer levels**		
	B_1: No Bio fertilizer	0.29	0.18
	B_2: *Azotobacterchroococcum* inoculation @ 5 ml/kg seed	0.30	0.18
	S.Em. ±	0.001	0.001
	C.D. at 5%	NS	NS
C.	**Nitrogen levels**		
	N_1: 75% RDN	0.29	0.18
	N_2: 100% RDN	0.30	0.18
	S.Em. ±	0.001	0.001
	C.D. at 5%	NS	NS
Interactions			
V × B		NS	NS
V × N		NS	NS
B× N		NS	NS
V × B × N		NS	NS
C.V.%		5.92	5.50

Table 3: Effect of vermicompost, bio fertilizer and nitrogen on potassium content of grain and straw of wheat

Treatments		Potassium content (%)	
		Grain	Straw
A.	**Vermicompost levels**		
	V_1: No vermicompost	0.38	0.97
	V_2: 2 t/ha vermicompost	0.39	0.99
	V_3: 4 t/ha vermicompost	0.38	0.99
	S.Em. ±	0.01	0.01
	C.D. at 5%	NS	NS
B.	**Bio fertilizer levels**		
	B_1: No Bio fertilizer	0.38	0.98
	B_2:*Azotobacterchroococcum* inoculation @ 5 ml/kg seed	0.39	0.99
	S.Em. ±	0.01	0.01
	C.D. at 5%	NS	NS
C.	**Nitrogen levels**		
	N_1:75% RDN	0.38	0.97
	N_2:100% RDN	0.39	1.00
	S.Em. ±	0.01	0.01
	C.D. at 5%	NS	NS
Interactions			
V × B		NS	NS
V × N		NS	NS
B× N		NS	NS
V × B × N		NS	NS
C.V.%		6.31	5.18

Table 4: Effect of vermicompost, bio fertilizer and nitrogen on available nutrients after harvest of wheat

	Treatments	Available nutrients after harvest (kg/ha)		
		N	P_2O_5	K_2O
A.	**Vermicompost levels**			
	V_1: No vermicompost	159.71	39.49	323.63
	V_2: 2 t/ha vermicompost	169.03	40.82	328.13
	V_3:4 t/ha vermicompost	177.66	41.85	332.80
	S.Em. ±	2.06	0.80	4.43
	C.D. at 5%	6.06	NS	NS
B.	**Bio fertilizer levels**			
	B_1:No Bio fertilizer	164.82	40.20	327.10
	B_2: *Azotobacterchroococcum* sinoculation @ 5 ml/kg seed	172.78	41.24	329.28
	S.Em. ±	1.69	0.33	3.62
	C.D. at 5%	4.94	NS	NS
C.	**Nitrogen levels**			
	N_1: 75% RDN	165.07	39.86	326.51
	N_2: 100% RDN	172.53	41.58	329.87
	S.Em. ±	1.69	0.66	3.62
	C.D. at 5%	4.94	NS	NS
	Interactions			
	V × B	NS	NS	NS
	V × N	NS	NS	NS
	B× N	NS	NS	NS
	V × B × N	NS	NS	NS
	C.V.%	4.24	6.84	4.68
	Initial	165.80	43.80	330.87

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