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Response of wheat (*Triticum aestivum* L.) to different organic and inorganic sources of nutrients

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Abstract
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. 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, biofertilizer and nitrogen levels on growth, yield and economics of wheat. 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). The results indicated that significantly higher growth and yield parameters *viz*., plant height (85.1, 81.6, 82.5 cm), number of tillers per plant (3.72, 3.56, 3.62), dry matter accumulation at harvest (261.0, 242.5, 249.4 g/mrl), length of spike (10.9, 10.2, 10.4 cm), number of seeds per spike (40.16, 37.74, 37.93), grain weight per spike (1.52, 1.45, 1.48 g) and test weight (38.54, 37.28, 37.65 g) with individual application of 4 t/ha vermicompost, *Azotobacter chroococcum* inoculation @ 5 ml/kg seed and 100% RDN, respectively. 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, biofertilizer and nitrogen. The maximum net realization ₹ 58272/ha was secured with application of 2 t/ha vermicompost along with 100% RDN and biofertilizer inoculation.

Keywords: Wheat, vermicompost, biofertilizer and nitrogen

Introduction

About 35 per cent of the world's population directly or indirectly depends upon wheat for food and providing 20 per cent of human dietary and serving as the main source of protein in developing nations. Wheat (*Triticumaestivum* 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.

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) [18]. Wheat protein is known as gluten which provides the structural framework for the spongy, cellular texture of bread and bakery products. Apart from food purposes, wheat grains have also industrial importance for manufacturing paste, alcohol, gluten etc. Residues obtained after milling *i.e.* bran used as cattle feed. Wheat straw is utilized as a fodder for feeding the livestock and also useful in manufacturing mattresses, straw hats, paper and articles of art purposes. Wheat straw is also a good source of bedding material for livestock.

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. India, being the second largest producer of wheat all over the world, next to china, produce around 12 per cent of the world wheat. In India, it is cultivated in an area about 29.32 million hectares with total production of 103.60 million tonnes having productivity of 3053 kg/ha during 2019-20.

(Anon., 2020b). Three main species of wheat *viz., Triticum aestivum, Triticum durum* and *Triticum dicocum* are cultivated in India. However, *Triticum aestivum* and *Triticum durum* are popularly grown in Gujarat.

Azotobacter is one of the most important non- symbiotic N-fixing microorganisms and considered to be very important for fixation of N in non-leguminous plants Application of *Azotobacter* has been found to increase the yields of wheat, rice, maize, pearl millet and sorghum by 5 to 30% over control. Inoculation of soil or seed with Azotobacter is effective in increasing yield of crops in well manured soil with high organic matter content (Verma *et al*., 2006) [19]. Besides the ability to fix atmospheric nitrogen, azotobacter is also known to synthesize biologically active substances such as B-vitamins, Indole Acetic Acid and Gibberellins in pure culture (Ahmad *et al*., 2005) [1]. These hormones stimulate root growth and development followed by accelerated uptake of plant nutrients from applied chemical fertilizers.

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. Therefore, judicious use of nitrogen has vital importance to exploit the production potential of crop.

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 24º 19' North latitude and 72º 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 biofertilizer *viz*. B_1: No biofertilizer, B_2: *Azotobacte rchroococcum* 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 per cent 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.

Vermicompost was applied 30 Days before sowing as per treatment. The entire quantity of recommended dose of phosphorus and half dose of nitrogen in the form of SSP and urea respectively were manually applied before sowing of wheat crop in the furrows as per treatments. The remaining half dose of nitrogen was applied in the form of urea at CRI stage after 1st irrigation to each plot as per treatment.

Results and Discussion

Plant population

The plant population of wheat was counted per metre row length at 20 DAS and at harvest and data have been presented in Table 1.

Effect of vermicompost

A perusal of data presented in Table 1 revealed that various levels of vermicompost did not exert their significant effect on plant population per metre row length recorded at 20 DAS and at harvest of wheat. The maximum number of plants 27.4 and 26.2 per meter row length were counted with treatment V_3 (4 t/ha vermicompost) at 20 DAS and harvest, respectively.

Effect of biofertilizer

The effect of *Azotobacter* inoculation on plant population at 20 DAS and harvest was found to be non-significant at both stages. (Table 1)

Effect of nitrogen levels

The data displayed in Table 1 revealed that various levels of nitrogen did not exert their significant effect on plant population per metre row length recorded at 20 DAS and harvest of wheat.

Plant height

The data of plant height recorded at 30 DAS, 60 DAS and harvest as influenced by different levels of vermicompost, biofertilizer and nitrogen have been presented in Table 2. Its analysis of variance is presented in Appendix-I and graphically depicted in Fig 1.

Effect of vermicompost

There was progressive increase in plant height with increased levels of vermicompost at various growth stages of wheat (Table 2). Effect of various levels of vermicompost on plant height at 30 DAS was found non-significant due to slow mineralization of vermicompost but application of 4 t/ha vermicompost produced the maximum plant height (30.3 cm) at 30 DAS.

Treatment V_3 (4 t/ha vermicompost) recorded significantly higher plant height (59.8 cm and 85.1 cm) at 60 DAS and at harvest, respectively being on par with treatment V_2. Due to adequate and continuous supply of nutrients at later stages sufficient amount of nutrients by easy mineralization of vermicompost at a constant level that resulted in higher plant growth and height of wheat at later stages. These results are in conformity with Joshi *et al*. (2013) [10] and Dekhane *et al*. (2017) [8].

Effect of biofertilizer

Effect of biofertilizer on plant height at 30 DAS and 60 DAS was found to be non-significant although seed treatment of *Azotobacter chroococcum* @ 5 ml/kg seed gave the maximum plant height at 30 DAS and 60 DAS (57.1 cm and 80.7 cm, respectively).

Treatment B_2 **(***Azotobacter chroococcum* inoculation @ 5 ml/kg seed) recorded significantly. The highest plant height (81.6 cm) at harvest. This might be due to nitrogen provided through non symbiotic fixation of atmospheric nitrogen and growth regulators produced by *Azotobacter*. It may also be caused due to solubilization of insoluble nitrogen by the production of various organic acids. The maximum values of plant height were observed under with inoculation treatment because plants were able to receive more nutrients. The results are in conformity with Bahrani *et al*. (2010) [5], Singh *et al*. (2016) [17] and Deepa *et al*. (2019) [7].

Effect of nitrogen

Effect of nitrogen on plant height at 30 DAS was found to be non-significant although increased nitrogen level (100% RDN) numerically produced taller plant (30.2 cm) at 30 DAS. Treatment N_2 application of 100% RDN recorded significantly the highest plant height at 60 DAS and at harvest (58.8 cm and 82.5 cm), respectively. The increase in plant height with increase in successive level of nitrogen might be due to more supply of nitrogen to crop resulting in rapid synthesis of carbohydrates and consequently converted into protoplasm and thereby smaller portion available for cell wall formation. This has served consequences of increase in size of cell which is expressed morphologically through increase in plant height. The results are in conformity with Kaur *et al*. (2015) [11] and Satyanarayana *et al.* (2017) [15].

Number of tillers per plant

The data on number of tillers per plant as influenced by different levels of vermicompost, biofertilizer and nitrogen have been presented in Table 3.

Effect of vermicompost

Application of vermicompost exerted their significant influence on number of tiller per plant (Table 3). Treatment V_3 (4 t/ha vermicompost) recorded significantly higher number of tillers per plant (3.72) compared to other treatment but being at par with treatment V_2 (2 t/ha vermicompost) which produced 3.52 number of tiller per plant. The Lower number of tillers per plant recorded found in treatment V_1 (no vermicompost). This might be due to more vegetative growth and growth attributes obtained through the availability of nutrients from deeper layers as roots penetrate into deeper layers in plots treated with vermicompost application. These results are conformity with Channabasanagowda *et al.* (2008) [6] and Dekhane *et al*. (2017) [8].

Effect of biofertilizer

Stastically biofertilizer application failed to significant influence on number of tillers per plant. Seed inoculation with *Azotobacter chroococcum* @ 5 ml/kg of seed (B_2) recorded the maximum number of tillers per plant (3.56) as compared to without seed inoculation (B_1) with the value of (3.38). These results are closely accordance with Kushare *et al*. (2009) [12] and Singh *et al*. (2016) [17].

Effect of nitrogen levels

An appraisal of data tabulated in Table 3 revealed that different nitrogen levels showed their significant effect on number of tillers per plant. Application of 100% RDN (N_2) recorded significantly the highest number of tiller per plant (3.62) while the lowest number of tillers per plant (3.31) was recorded under 75% RDN (N_1). The higher number of tillers per plant may be due to sufficient availability of nitrogen to the root of the crop. Higher availability of nitrogen may increase the nutrition to active growing part of plant which have the ability to multi shooting with favorable condition and that's why ultimately leads to higher shooting of the tillers to the base of the plant. The results are in conformity with Ali *et al.* (2011) and Kaur *et al*. (2015) [2, 11].

Grain yield

The data on grain yield as influenced by different levels of vermicompost, biofertilizer and nitrogen have been presented in Table 4. The data are also graphically presented in Fig. 2.

Effect of vermicompost

A perusal of data displayed in Table 4 revealed that various levels of vermicompost significantly influence on grain yield of wheat. Treatment V_3 (4t/ha vermicompost) recorded significantly the highest grain yield (4857 kg/ha). The lowest grain yield (3400 kg/ha) was recorded under treatment V_1 (no vermicompost). Whereas, 4 t/ha vermicompost produced 22% and 43% higher grain yield over V_2 and V_1 treatments.

From this result it may be inferred that the beneficial effect of vermicompost is due to its contribution in supplying additional plant nutrients, improvement of soil physical, chemical and biological process in soil which lead to favourable influence on soil physical properties leading to increased root growth resulted in improvement of no. of tiller/plant, test weight and ultimately grain yield of wheat. The results conformity with Verma *et al*. (2016) [20], Dekhane *et al*. (2017) [8] and Hadis *et al*. (2018) [9].

Effect of biofertilizer

Biofertilizer application recorded significant effect on grain yield. Significantly the highest grain yield (4271 kg/ha) of wheat was recorded with treatment B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed), while the lower grain yield (3887 kg/ha) was recorded under without seed inoculation (B_1). Treatment B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed) produced 9.87% higher grain yield compared to without seed inoculation (B_1).

In the present investigation inoculation of *Azotobacter* increased the yield due to increase in source capacity *viz*. plant height, length of spike, number of seeds per spike, grain weight per spike as well as sink capacity. It might be due to inoculation of seeds with *Azotobacter* improved N status of soil and ultimately increased N uptake which enhanced the yield of the crop. The results are supported by Singh *et al*. (2016) [17], Bahlool *et al.* (2019) [4] and Deepa *et al*. (2019) [7].

Effect of nitrogen

Significant effect of different nitrogen levels on grain yield was observed. Treatment N_2 (100% RDN) recorded significantly the highest grain yield (4340 kg/ha). The lowest grain yield (3818 kg/ha) was recorded under treatment N_1 (75% RDN). Treatment N_2 (100% RDN produced 13.67% higher grain yield compared to treatment N_1 (75% RDN).

This may be mainly attributed to improved growth and yield parameters *viz*., plant height, length of spike, number of seeds per spike, grain weight per spike and the beneficial effects of nitrogen on cell division and elongation, formation of nucleotides and co-enzymes which resulted in increased meristematic activity and photosynthetic area and hence more production and accumulation of photosynthates, yielding higher grain yield. The results are in close conformity with those reported by Pandey *et al*. (2014) [14], Kaur *et al*. (2015) [11] and Satyanarayana *et al.* (2017) [15].

Straw yield

The data on straw yield as influenced by different levels of vermicompost, biofertilizer and nitrogen have been presented in Table 5. Its analysis of variance is presented in Appendix E. The data are also graphically presented in Fig. 2.

Effect of vermicompost

A perusal of data showed in Table 5 revealed that various levels of vermicompost significantly influenced on straw yield. Treatment V_3 (4t/ha vermicompost) recorded significantly the highest straw yield (6038 kg/ha). The lowest straw yield (4121 kg/ha) was recorded under treatment V_1 (no vermicompost). Whereas, application of 4 t/ha vermicompost produced 23.5% and 47% higher straw yield compared to 2 t/ha and no vermicompost respectivly. The results are close conformity with finding of Verma *et al*. (2016) [20] and Dekhane *et al*. (2017) [8].

Effect of biofertilizer

The results presented in Table 5 revealed that various levels of biofertilizer had significant effect on influence with straw yield. Significantly the highest straw yield (5263 kg/ha) of wheat was recorded with treatment B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed). While the lower straw yield (4769 kg/ha) was recorded under without seed inoculation treatment (B_1). Treatment B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed) produced 10% higher straw yield compared to without seed inoculation (B_1). Increase in straw yield might be due to the cumulative influence of *Azotobacter* leads to improvement in growth parameters of the crop through the more availability of nitrogen to the plant. The results are closely related with Singh *et al*. (2016) [17] and Deepa *et al*. (2019) [7].

Effect of nitrogen

The data presented in Table 5 showed that there was significant effect of different nitrogen levels on straw yield. Treatment N_2 (100% RDN) recorded significantly the highest straw yield (5363 kg/ha). The lowest straw yield (4669 kg/ha) was recorded under treatment N_1 (75% RDN). Treatment N_2 (100% RDN produced 15% higher straw yield than treatment N_1 (75% RDN).

The increased straw yield per plant with the application of 100% RDN seems to be on account of increased photosynthetic efficiency and greater development of vegetative structure. It might be due to RDN apply in form of urea which contain N readily available form which leads better root and shoot development while nitrogen leads improve the supply of nutrients increased photosynthetic area and thereby ultimately resulted into higher values of yield and yield attributing characters. The results are in close proximity with finding of conformity with Shirazi *et al.* (2014) [16] and Pandey *et al*. (2014) [14].

Table 1: Effect of vermicompost, biofertilizer and nitrogen levels on plant population at 20 DAS and at harvest of wheat

Treatments		Plant population per metre row length	
		At 20 DAS	At harvest
A.	**Vermicompost levels**		
	V_1: No vermicompost	26.6	25.2
	V_2: 2 t/ha vermicompost	27.2	25.9
	V_3: 4 t/ha vermicompost	27.4	26.2
	S.Em. ±	0.7	0.7
	C.D. at 5%	NS	NS
B.	**Biofertilizer levels**		
	B_1: No biofertilizer	26.8	25.5
	B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed	27.4	26.0
	S.Em. ±	0.6	0.5
	C.D. at 5%	NS	NS
C.	**Nitrogen levels**		
	N_1: 75% RDN	26.7	25.4
	N_2: 100% RDN	27.4	26.0
	S.Em. ±	0.6	0.5
	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.%		9.5	9.7

Table 2: Effect of vermicompost, biofertilizer and nitrogen on plant height at 30 DAS, 60 DAS and at harvest of wheat

Treatments		Plant height (cm)		
		30 DAS	60 DAS	At harvest
A.	**Vermicompost levels**			
	V_1: No vermicompost	29.3	53.7	71.9
	V_2: 2 t/ha vermicompost	30.0	57.1	80.7
	V_3: 4 t/ha vermicompost	30.3	59.8	85.1
	S.Em. ±	0.8	1.6	1.9
	C.D. at 5%	NS	4.7	5.6
B.	**Biofertilizer levels**			
	B_1: No biofertilizer	29.6	56.0	76.9
	B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed	30.1	57.8	81.6
	S.Em. ±	0.7	1.3	1.6
	C.D. at 5%	NS	NS	4.6
C.	**Nitrogen levels**			
	N_1: 75% RDN	29.5	54.9	76.1
	N_2: 100% RDN	30.2	58.8	82.5
	S.Em. ±	0.7	1.3	1.6
	C.D. at 5%	NS	3.8	4.6
Interactions				
V × B		NS	NS	NS
V × N		NS	NS	Sig.
B × N		NS	NS	NS
V × B × N		NS	NS	NS
C.V.%		9.68	9.72	8.32

Table 3: Effect of vermicompost, biofertilizer and nitrogen levels on number of tiller per plant of wheat

Treatments		Number of tillers per plant
A.	**Vermicompost levels**	
	V_1: No vermicompost	3.17
	V_2: 2 t/ha vermicompost	3.52
	V_3: 4 t/ha vermicompost	3.72
	S.Em. ±	0.09
	C.D. at 5%	0.26
B.	**Biofertilizer levels**	
	B_1: No Biofertilizer	3.38
	B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed	3.56
	S.Em. ±	0.07
	C.D. at 5%	NS
C.	**Nitrogen levels**	
	N_1: 75% RDN	3.31
	N_2: 100% RDN	3.62
	S.Em. ±	0.07
	C.D. at 5%	0.21
Interactions		
V × B		NS
V × N		Sig.
B × N		NS
V × B × N		NS
C.V.%		8.83

Table 4: Effect of vermicompost, biofertilizer and nitrogen levels on grain yield of wheat

Treatments		Grain yield (kg/ha)
A.	**Vermicompost levels**	
	V_1: No vermicompost	3400
	V_2: 2 t/ha vermicompost	3980
	V_3: 4 t/ha vermicompost	4857
	S.Em. ±	134
	C.D. at 5%	393
B.	**Biofertilizer levels**	
	B_1: No Biofertilizer	3887
	B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed	4271
	S.Em. ±	109
	C.D. at 5%	321
C.	**Nitrogen levels**	

	N_1: 75% RDN	3818
	N_2: 100% RDN	4340
	S.Em. ±	109
	C.D. at 5%	321
Interactions		
V × B		NS
V × N		Sig.
B × N		NS
V × B × N		NS
C.V.%		11.36

Table 5: Effect of vermicompost, biofertilizer and nitrogen levels on straw yield of wheat

Treatments		**Straw yield (kg/ha)**
A.	**Vermicompost levels**	
	V_1: No vermicompost	4121
	V_2: 2 t/ha vermicompost	4889
	V_3: 4 t/ha vermicompost	6038
	S.Em. ±	173
	C.D. at 5%	507
B.	**Biofertilizer levels**	
	B_1: No Biofertilizer	4769
	B_2: *Azotobacter chroococcum* inoculation @ 5 ml/kg seed	5263
	S.Em. ±	141
	C.D. at 5%	414
C.	**Nitrogen levels**	
	N_1: 75% RDN	4669
	N_2: 100% RDN	5363
	S.Em. ±	141
	C.D. at 5%	414
Interactions		
V × B		NS
V × N		Sig.
B × N		NS
V × B × N		NS
C.V.%		11.94

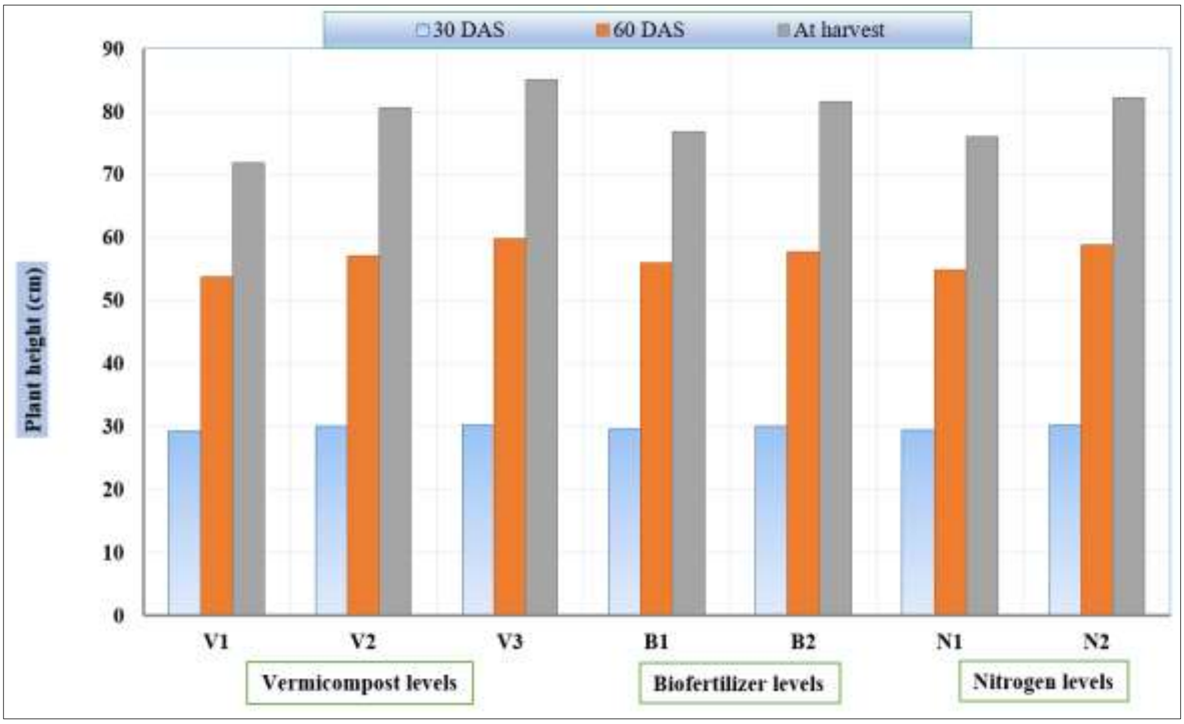

Fig 1: Effect of vermicompost, biofertilizer and nitrogen levels on plant height at 30 DAS and at harvest of wheat

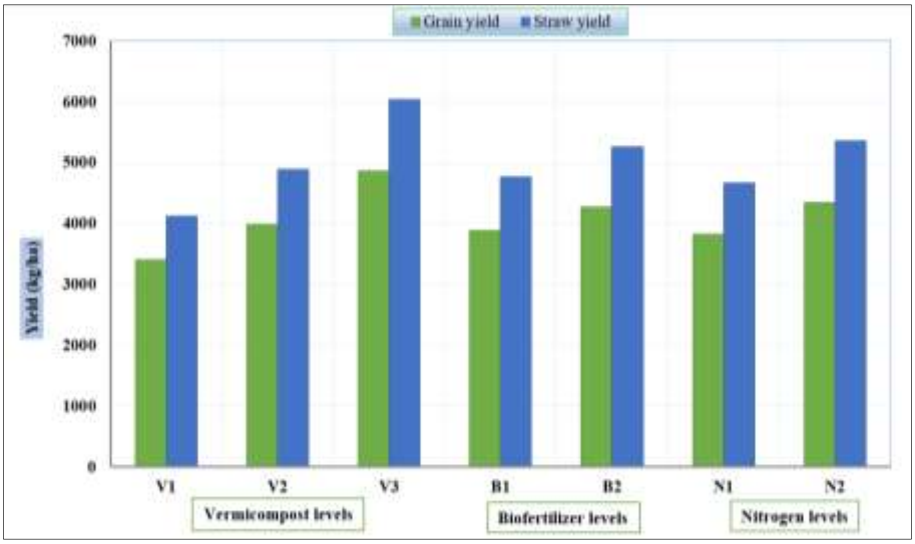

Fig 2: Effect of vermicompost, biofertilizer and nitrogen levels on grain yield and straw yield wheat

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