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Growth and yield attainment of wheat under different levels of vermicompost, biofertilizers and nitrogen

Lalita H Saini, AK Saini, SH Malve, Jaykumar P Patel and Brihma Nand and HS Chaudhary

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, 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 experiment was laid out in Randomized Block Design (Factorial concept) and replicated thrice. Twelve treatment combinations consisting three levels of vermicompost, two levels of biofertilizer and two levels of nitrogen were embedded. 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. Thus, it is concluded that for securing higher grain and straw yield the wheat seed should be inoculated with *Azotobacter chroococcum* @ 5 ml/kg seed and crop should be fertilized with 90 kg nitrogen per ha (two splits, *i.e*. 50% as basal and 50% at 21 days after sowing) along with application of 4 t vermicompost and phosphorus 60 kg per ha as basal application in loamy sand.

Keywords: Biofertilizer, *Azotobacter chroococcum*

Introduction
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. 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.
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) [2]. Three main species of wheat *viz., Triticum aestivum, Triticum durum* and *Triticum dicoccum* are cultivated in India. However, *Triticum aestivum* and *Triticum durum* are popularly grown in Gujarat.
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) [18]. On an average vermicompost contains nitrogen 2-3%, potassium 1.85-2.25% and phosphorus 1.55-2.25% (Sinha, 2009) [25]. Vermicompost contains different types of soil beneficial microbes that can improve plant growth through vitamins, hormones and antibodies (Lourduraj, 2006) [12]. Vermicompost also contains different enzymes which are responsible for degradation of large organic molecules for enhancement of further microbial activity (Gupta, 2003) [8]. It is also advantageous in preventing leaching of nutrients and even in conserving nutrients, bacterial, valuable enzymes and vitamins in soil.
Soil fertility and other agronomic practices play an indispensable role in determining the

economic yield of wheat with good quality. Fertilizer has been continue to be the key input for achieving the estimated food grain production goals of the country. The importance of nitrogen application to wheat crop has been recognized since long and is the backbone of any fertilizer management programme. It is most important nutrient and it is consumed in more quantity than P and K.

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) [13]. Nitrogen management is important in improving quality and productivity of wheat (Patel *et al.*, 2004) [16].

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 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 biofertilizer *viz.* B_1: No biofertilizer, 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 randomizedblock design with three replications.Dates of all operations were noted; data collected includinggrowth 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.

Results and Discussion

Effect of vermicompost

Plant height

There was progressive increase in plant height with increased levels of vermicompost at various growth stages of wheat (Table 1). 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 Nehra *et al*. (2001) [14], Joshi *et al*. (2013) [9] and Dekhane *et al*. (2017) [7].

Test weight

A perusal of data presented in 2 showed that various levels of vermicompost had significantly effect on test weight. Treatment V_3 (4 t/ha vermicompost) recorded significantly higher test weight (38.54 g) over other treatment. The lowest test weight (33.42 g) was recorded under treatment V_1 (no vermicompost).

Grain yield

A perusal of data displayed in Table 2 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.

Straw yield

A perusal of data showed in Table 2 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 respectively. From these results 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 due to favourable influence on soil physical properties leading to increased root & shoot growth and ultimately straw yield of wheat.

Effect of biofertilizer

Plant height

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 Bindia *et al.* (2005) [5], Kushare *et al*. (2009) [11], Bahrani *et al.* (2010) [4], Singh *et al*. (2016) [23] and Deepa *et al*. (2019) [6].

Test weight

Various levels of biofertilizer had found non-significant effect on test weight. The maximum test weight (37.28g) of wheat was recorded under treatment B_2 (*Azotobacter chroococcum* inoculation @ 5 ml/kg seed). While the minimum test weight (34.98 g) was recorded under without seed inoculation (B_1).

Grain yield

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.* (2013) [24], Singh *et al*. (2016) [23], Bahlool *et al.* (2019) [3] and Deepa *et al*. (2019) [6].

Straw yield

The results presented in Table 2 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 Singh *et al*. (2016) [23] and Deepa *et al*. (2019) [6].

Effect of nitrogen levels

Plant height

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 Ali *et al.* (2011) [1], Patel *et al.* (2012) [17], Kaur *et al*. (2015) [10] and Satyanarayana *et al.* (2017) [21].

Test weight

Test weight of affected by significantly due to nitrogen levels. Application of @ 100% RDN recorded significantly higher test weight 37.65 g 75% RDN with the value of 34.61 g. The increased test weight per plant with the application of while 100% RDN seems to be on account of increased photosynthetic efficiency which leads heavier grain leading higher test weight. The finding are close conformity with those reported by Kumar and Yadav (2005) [26] and Ali *et al.* (2011) [1].

Grain yield

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 Ali *et al.* (2011), Patel *et al.* (2012) [17], Rahimi (2012) [20], Pradhan *et al.* (2013) [19], Singh *et al.* (2013) [24]

Straw yield

The data presented in Table 2 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 results are in close proximity with finding of conformity Patel *et al.* (2012) [17], Rahimi (2012) [20], Singh *et al.* (2013) [24], Shirazi *et al.* (2014) [22] and Pandey *et al.* (2014) [15].

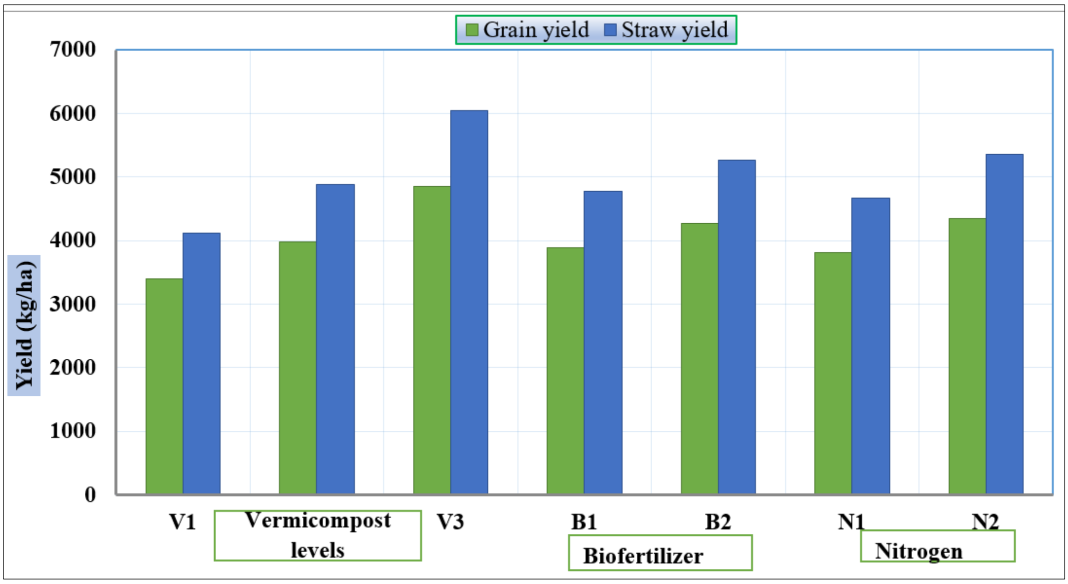

Fig 1: Effect of vermicompost, biofertilizer and nitrogen levels on grain yield and straw yield wheat

Table 1: Effect of vermicompost, biofertilizer and nitrogen levels on growth of wheat at different stages

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	:	*Azotobacterchroococcum* 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
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 2: Effect of vermicompost, biofertilizer and nitrogen levels on test weight, grain yield and straw yield of wheat

Treatments				Test weight (g)	Grain yield (kg/ha)	Straw yield (kg/ha)
A.	Vermicompost levels					
	V_1	:	No vermicompost	33.42	3400	4121
	V_2	:	2 t/ha vermicompost	36.43	3980	4889
	V_3	:	4 t/ha vermicompost	38.54	4857	6038
	S.Em. ±			1.21	134	173
	C.D. at 5%			3.56	393	507
B.	Biofertilizer levels					
	B_1	:	No Biofertilizer	34.98	3887	4769
	B_2	:	*Azotobacterchroococcum* inoculation @ 5 ml/kg seed	37.28	4271	5263
	S.Em. ±			0.99	109	141
	C.D. at 5%			NS	321	414
C.	Nitrogen levels					
	N_1	:	75% RDN	34.61	3818	4669
	N_2	:	100% RDN	37.65	4340	5363
	S.Em. ±			0.99	109	141

C.D. at 5%	2.90	321	414
Interactions			
V × B	NS	NS	NS
V × N	NS	Sig.	Sig.
B × N	NS	NS	NS
V × B × N	NS	NS	NS
C.V.%	11.63	11.36	11.94

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