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Effect of organic and inorganic fertilizers on growth and yield of wheat (*Triticum aestivum* L.)

Gulshan Kumar and Ram Niwas

Abstract
This study was conducted on Effect of organic and inorganic fertilizers on growth and yield of wheat (*Triticum aestivum* L.) during the Rabi season of 2020-21 on Agricultural Farm of RAMA UNIVERSITY, KANPUR,209217, (U.P.) INDIA. The experiment was laid out in Simple RBD with 9 treatments replicated thrice. The treatments were T_1 Control, T_2 (100% (NPK 120:60:40 kg ha^{-1}), T_3 75% (NPK) + 10 t ha^{-1}FYM, T_4 (50% (NPK) + 15 t ha^{-1} FYM), T_5 (75% NPK + 10 t ha^{-1} vermicompost), T_6 (50% NPK + 15 t ha^{-1} vermicompost), T_7 (75% NPK + 5 t ha^{-1} poultry manure, T_8 (75% NPK + 5 t/ ha^{-1}press mud), T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB). From our experiment it was found that the Treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB), was found best in the terms of, Plant population, Plant height, Dry matters, Number of tillers, number of effective tillers, leaf area index, days taken to flowering, length of ear, number of spike, number of spikelet/ear, number of grain per ear, biological yield, grain yield, straw yield, harvest index and B:C ratio.

Keywords: NPK, FYM, Poultry manure, Vermicompost, PSB and Press mud

Introduction

Wheat is a grass widely cultivated for its seed, a cereal grain which is a world wide staple food. The many species of wheat together make up the genus *Triticum*; the most widely grown is common wheat (*T. aestivum*). The archaeological record suggests that wheat was first cultivated in the regions of the Fertile Crescent around 9600 BCE. Botanically, the wheat kernel is a type of fruit called a caryopsis. Wheat is auto hexaploid having the chromosome number of 6x = 42.

After rice, wheat is the world's second most important annual cereal crop. China, India, the United States of America, Canada, Australia, the Soviet Union, Spain, and France are among the countries that cultivate wheat as a major cereal crop.

In India, the wheat crop, which is planted on 25.1 million hectares, produced an all-time high of 68.7 million metric tones, setting a new record for wheat production. Wheat production in India reached 60.0 million metric tones for the first time in 1995.

Despite applying the prescribed fertilizers dose, the crop's yield potential has plateaued due to degradation of soil health in terms of depletion of organic matter and nutrients. It is consequently imperative to maintain and/or improve soil fertility for long-term crop production through the use of organic manures and biofertilizers in conjunction with chemical fertilizers.

Organic manures are a great way to give nutrients to the soil. They not only feed the plants, but they also improve the soil's physical features, such as infiltration, water holding capacity, aeration permeability, soil aggregation, rooting depth, decreased soil crusting, bulk density, and water and wind erosion. These also stimulate biological activity in the soil, reducing pathogen populations.

Azotobacter, on the other hand, is one of the free living microorganisms that fixes the atmospheric nitrogen and makes it available to plants. Inoculation of Azotobacter also improves the yield and quality of crop (Sahrma *et al.*, 1987). So, cutting down of adversely affecting inputs such as chemical fertilizers with other safe substitute is very important for sustaining the biological productivity of the soil. Azotobacter is a non-symbiotic, free-living nitrogen-fixing bacteria that also produces enzymes and antibiotics that are not only nutritionally stimulating but also therapeutic for plant growth, yield, and quality. Azotobacter has a nitrogen fixation capacity of 25 to 30 kg per hectare. (Bhattacharyya *et al.*, 2000).

An application of vermicompost and straw of different crops with PSB and *Azotobacter* reported by many workers to produced higher grain and straw yield.

Chemical fertilizers, agro-chemicals, and bio-fertilizers are used to increase wheat output; however, their usage places a chemical strain on the environment, potentially resulting in soil health loss and environmental deterioration. As a result, encouraging pulse production through the use of organic sources of nutrients such as bio-fertilizers in a rich environment has become vital. Bio-fertilizers have the potential to be the "driving force" behind long-term crop production while also enhancing soil health and fertility. Switching to bio-fertilizers for proper crop production can actually bring in 'economic prosperity' for farmers and the nation, as well as 'environmental security' for the planet. Soil includes natural stocks of plant nutrients, most of which are in forms that plants can't use. Each year, a portion of these nutrients is released into the environment through biological or chemical processes and made available to plants. Plant nutrition affects all plant communities, including wheat crops, in terms of growth, output, and productivity.

Materials and Methods

Climatic Condition of Kanpur

Geographically, Kanpur is situated in sub tropical region at an altitude of 125.9 meter from the mean sea level and latitude ranging of 25^0 56' to 28° 58' North and longitude 79° 31' to 80° 34' East. The climate of locality is semi arid with moderate rainfall and cold winters. The mean annual rainfall is 850 mm extending generally from the mid June to mid October. The temperature rises maximum during May - June (45 - 48°C) and come down to 4 -5 ^0C during December - January. Occasional showers are also received during winter and summer**.**

The experiment was conducted in Randomized Block Design (RBD) with one control and 8 treatments and three replications at Students Instructional Farm of Rama University, Kanpur during *Rabi* (2020-21).The treatments were T_1 Control, T_2 (100% (NPK 120:60:40 kg ha^{-1}), T_3 75% (NPK) + 10 t ha^{-1}FYM, T_4 (50% (NPK) + 15 t ha^{-1} FYM), T_5 (75% NPK + 10 t ha^{-1} vermicompost), T_6 (50% NPK + 15 t ha^{-1} vermicompost), T_7 (75% NPK + 5 t ha^{-1} poultry manure, T_8 (75% NPK + 5 t/ ha^{-1}press mud), T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB).

Experimental Findings

The effect of organic and inorganic fertilizer is very obvious and consistent. There was significant difference among the application of the different treatment and among the treatment applied treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (125.64 plants m^{-2}) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (124.45 plants m^{-2}) which were significantly superior over T_1 (Control) with (117.85 plants m^{-2}).

The maximum plant height was recorded in the treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with 92.35 cm followed by the treatment T_6 (50% NPK + 15 t ha^{-1} vermicompost) with 89.56 cm and the minimum height were recorded in the T_1 (Control) with 74.89 cm.

The maximum dry weight was recorded in the treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with 71.59 g followed by the treatment T_6 (50% NPK + 15 t ha^{-1} vermicompost) with 67.89 g and the minimum dry weight were recorded in the T_1 (Control) with 55.62 gram.

The maximum number of tillers was recorded in the treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with 468 followed by the treatment T_6 (50% NPK + 15 t ha^{-1} vermicompost) with 462 and the minimum number of tillers were recorded in the T_1 (Control) with 451.

There was significant difference among the application of the different treatment on number of effective tillers and among the treatment applied treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (360.59) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (335.7) which were significantly superior over T_1 (Control) with (305.8) number of effective tillers.

The maximum number of leaf area index was recorded in the treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with 6.7 followed by the treatment T_6 (50% NPK + 15 t ha^{-1} vermicompost) with 6.48 and the minimum number of leaf area index were recorded in the T_1 (Control) with 5.65.

There was significant difference among the application of the different treatment on DAS taken to 80% flowering and among the treatment applied treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (75.69) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (78.95) which were significantly superior over T_1 (Control) with (94.68) DAS taken to 80% flowering.

The maximum length of ear was found in T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (9.56 cm) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (9.12 cm) which were significantly better over T_1 (Control) with (7.83 cm) Length of ear.

The maximum number of spike was found in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (345.67) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (312.85) which were significantly superior over T_1 (Control) with (175.65) Number of Spike.

The maximum number of Spikelet per ear was found in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (18.25) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (17.02) which were significantly superior over T_1 (Control) with (15.25) Number of Spikelet per ear.

The maximum number of grain/ear were seen in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (44.56) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (43.91) which were significantly superior over T_1 (Control) with (38.02) Number of grain/ear.

The maximum test weight was observed in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (47.56) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (46.28) which were significantly superior over T_1 (Control) with (38.78) Test weight.

The maximum biological yield was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (10608 kg ha^{-1}) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (10454 kg ha^{-1}) which were significantly superior over T_1 (Control) with (9342 kg ha^{-1}) Biological yield. The maximum grain yield was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (4469 kg ha^{-1}) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (4385 kg ha^{-1}) which were significantly superior over T_1 (Control) with (3874 kg ha^{-1}) Grain yield.

The maximum straw yield was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (6139 kg ha^{-1}) followed by T_6 (50% NPK + 15 t ha^{-1}

vermicompost) with (6069 kg ha^{-1}) which were significantly superior over T_1 (Control) with (5468 kg ha^{-1}) Straw yield.

The maximum harvest index was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (42.10) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (42.02) which were significantly superior over T_1 (Control) with (40.08) Harvest index.

The maximum B:C ratio was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (2.88) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (2.40) which were significantly superior over T_1 (Control) with (2.70).

The maximum electrical conductivity was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (0.28) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (0.25) which were significantly superior over T_1 (Control) with (0.24) electrical Conductivity.

The maximum pH was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (8.4) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (8.01) which were significantly superior over T_1 (Control) with (7.25) pH.

The maximum O.C. was obtained in treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (0.42) followed by T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (0.39) which were significantly superior over T_1 (Control) with (0.36) Organic Carbon.

The maximum available N, P, K was seen in the treatment T_9 (100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB) with (237.1, 22.50, 330.00 kg ha^{-1} N, P, K respectively) followed by the treatment T_6 (50% NPK + 15 t ha^{-1} vermicompost) with (226.80, 20.40, 313.00 kg ha^{-1} N, P, K respectively) and the minimum was obtained in the T_1 (Control) with (114.70, 9.10, 257.00 kg ha^{-1} N, P, K respectively).

Table 1: Effect of Organic and Inorganic fertilizers on Plant population, Plant height, Dry weight (g plant^{-1}), Numbers of tillers m^{-2}

Symbols	Treatment	Plant Population	Plant Height (cm)				Dry weight (g plant^{-1})				Numbers of tillers m^{-2}			
			30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest	45 DAS	60 DAS	90 DAS	120 DAS
T_1	Control	117.85	16.52	42.50	69.89	74.89	7.64	42.35	51.26	55.62	421	441	455	451
T_2	100% (NPK 120:60:40 kg ha^{-1})	119.34	16.68	46.90	71.36	76.36	8.21	51.23	60.56	63.45	423	443	458	453
T_3	75% (NPK) + 10 t ha^{-1}FYM	120.34	17.35	48.60	73.46	78.65	8.09	53.76	61.59	64.59	424	444	459	454
T_4	50% (NPK) + 15 t ha^{-1} FYM	122.65	17.46	49.50	76.89	81.56	7.92	55.31	63.25	64.98	426	446	460	456
T_5	75% NPK + 10 t ha^{-1} vermicompost	122.02	18.64	50.20	75.98	80.64	8.64	56.10	63.01	65.59	428	448	463	458
T_6	50% NPK + 15 t ha^{-1} vermicompost	124.45	20.64	51.85	84.56	89.56	8.95	57.36	64.25	67.89	432	452	467	462
T_7	75% NPK + 5 t ha^{-1} poultry manure	123.12	18.54	45.90	79.58	84.12	8.49	50.56	58.64	63.49	435	455	470	465
T_8	75% NPK + 5 t/ ha^{-1}press mud	123.89	21.46	47.59	77.56	82.31	8.34	55.67	56.98	62.59	436	456	471	466
T_9	100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB	125.64	22.5	53.56	88.68	92.35	9.28	58.33	68.95	71.59	438	458	473	468
	CD	4.564	NS	7.58	7.32	7.22	NS	6.58	6.32	7.39	12.34	13.45	13.95	14.05
	SE(d)	2.243	NS	3.54	3.42	3.37	NS	3.65	4.01	3.56	7.52	7.89	6.82	8.64

Table 2: Effect of Organic and Inorganic fertilizers on Effective tillers m^{-2} Leaf area Index, Days to 80% flowering, Length of ear (cm), Number of Spike m$^{-2,}$ Number of Spikelet ear^{-1} Grain ear^{-1} Test weight (g)

Symbols	Treatment	Effective tillers m^{-2}	Leaf area Index			Days to 80% flowering	Length of ear (cm)	Number of Spike (m^{-2})	Number of Spikelet ear^{-1}	Grain ear^{-1}	Test weight (g)
			30 DAS	60 DAS	90 DAS						
T_1	Control	305.8	0.62	3.71	5.65	94.68	7.83	175.65	15.25	38.02	38.78
T_2	100% (NPK 120:60:40 kg ha^{-1})	310.6	0.86	3.86	5.88	80.68	8.91	212.52	15.64	40.56	40.25
T_3	75% (NPK) + 10 t ha^{-1}FYM	315.6	1.21	4.21	6.27	85.67	8.95	285.64	15.86	42.35	43.56
T_4	50% (NPK) + 15 t ha^{-1} FYM	320.9	0.98	4.1	6.13	83.91	8.45	255.45	16.35	41.11	44.23
T_5	75% NPK + 10 t ha^{-1} vermicompost	331.8	0.75	3.83	5.9	90.56	8.75	245.91	16.59	42.56	39.67
T_6	50% NPK + 15 t ha^{-1} vermicompost	335.7	1.39	4.44	6.48	78.95	9.12	312.85	17.02	43.91	46.28
T_7	75% NPK + 5 t ha^{-1} poultry manure	348.6	1.15	4.25	6.21	88.64	8.55	298.64	16.45	41.42	41.49
T_8	75% NPK + 5 t/ ha^{-1}press mud	355.46	1.33	4.38	6.45	87.98	9.01	288.53	16.02	42.71	45.89
T_9	100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB	360.59	1.45	4.5	6.7	75.69	9.56	345.67	18.25	44.56	47.56
	CD	11.34	NS	6.32	7.39	7.95	0.242	4.689	0.934	1.917	NS
	SE(d)	5.68	3.65	4.01	3.56	3.71	0.114	2.345	0.44	0.904	0.72

Table 3: Effect of organic and inorganic fertilizers on Biological yield kg ha^{-1}, Grain yield kg ha^{-1}, Straw yield kg ha^{-1}, Cost of cultivation Rs ha^{-1}, Gross Income, Net Income, B:C Ratio

Symbols	Treatment	Harvest index %	Yield			Economics			
			Biological yield kg ha^{-1}	Grain yield kg ha^{-1}	Straw yield kg ha^{-1}	Cost of cultivation Rs ha^{-1}	Gross Income	Net Income	B:C Ratio
T_1	Control	40.08	9342	3874.00	5468	11904	32207	20303	2.70
T_2	100% (NPK 120:60:40 kg ha^{-1})	41.50	9475	3899.00	5576	12967	33534	20567	2.58
T_3	75% (NPK) + 10 t ha^{-1}FYM	41.76	9390	3907.00	5483	11967	32276	20309	2.69
T_4	50% (NPK) + 15 t ha^{-1} FYM	40.98	9485	3897.00	5588	12587	33461	20874	2.65
T_5	75% NPK + 10 t ha^{-1} vermicompost	41.80	9591	3954.00	5637	14910	34405	19495	2.30
T_6	50% NPK + 15 t ha^{-1} vermicompost	42.02	9957	4385.00	6069	13678	32892	19214	2.40
T_7	75% NPK + 5 t ha^{-1} poultry manure	41.86	9792	4201.00	5756	13776	33918	20142	2.46
T_8	75% NPK + 5 t/ ha^{-1}press mud	41.98	10608	4094.00	5698	13708	34388	20680	2.50
T_9	100% NPK +5 t ha^{-1} FYM + 5t ha^{-1} vermicompost + PSB	42.10	15.68	4469.00	6139	11789	33989	22200	2.88
	CD	NS	6.46	16.45	13.64				
	SE(d)	0.365	3.154	7.59	6.98				

Discussion

Effect on growth

Crop growth results from changes in a variety of morphological factors, including plant height, the number of tillers per metre of row length, leaf area, and the accumulation of dry matter. Any treatment that alters these variables will ultimately have an impact on the crop's overall growth. According to the study's findings, the crop's peak growing period occurred between 60 and 90 DAS, when all growth metrics rose at a quicker pace. Plant height, leaf area, and dry matter accumulation all gradually grew from 30 to 60 DAS, peaked between 60 and 90 DAS, and then began to fall. Different treatments had a substantial impact on plant height, the number of tillers per meter row length, the amount of leaf area per metre row length, the leaf area index, and the accumulation of dry matter.

An organism's size, dry weight, or volume will increase as a result of the irreversible process of growth. Plant growth is primarily influenced by the environment and the nutrients given to the plant, which contribute to the formation of yield attributes, yield characters, and yield in the end. The rate of increase in these growth parameters decreased at later stages of growth, with the exception of plant height, which continues to increase up until maturity due to the plants' heading. Plant height, number of tillers per metre, and leaf area index all increased gradually up until the crop's maturity. It might be because plants grow more quickly in the exponential phase and develop more height and tillers when they receive enough nutrients at various points during the vegetative growth phase. Because plants transitioned to the reproductive phase after the active vegetative growth stage, the rate of increase in plant height and tiller dropped. Fruit production took the place of the food that the plants had been using for growth up to this point. As a result, growth following the mid-growth stage was modest. Jadhav (2005)

Effect on Yield Attribute

This variation would have happened as a result of different treatments. The leaf area index and other plant surface areas to a lesser extent impact the photosynthetic activity of the plants. The majority of the dry matter accumulated by plants is carbon dioxide, which is produced during the photosynthesis process. Due to the abundant supply of nutrients, both the number of leaves per plant and the leaf area index demonstrate substantial influence. The results showed that various nutrient doses had a significant impact on the number of effective tillers per metre, weight of grain/ear, ear length, number of grains per ear, and test weight. The outcomes shown in various tables demonstrated that treatments using both organic and inorganic sources produced the greatest number of productive tillers. Similar trend was observed in other yield attributing characters like length of ear, number of grains per ear and 1000-grain weight. The results are in line with those of Reddi and Patil (2003) [30] and Sardana *et al*. (2002).

Yield Parameters

Effective tillers per metre of row length, ear length, number of spikelets, grain quantity, grain weight per ear, and test weight are the yield-contributing characteristics that determine wheat yield. According to the current research, fertility levels had a beneficial impact on yield qualities, and each character's significance increased as fertility levels rose. Due to superior yield-attributing qualities, higher fertility levels reacted favourably in plant growth characters. Increasing fertiliser levels enhanced grain yield and yield components. (Singh *et al*., 2007).

Effect of grain, straw and biological yield

The economically viable crop produced from a crop planted on a certain plot of land is known as the grain yield. It is the outcome of the crop's yield-attributing characteristics and growth parameters. The findings of this study show that adequate nutrition supply under various treatments significantly influenced grain and straw yields. The sum of a crop's yield-attributing characteristics is its yield. Any treatment's impact on yield qualities is clearly visible in the yield. In this investigation, various treatment doses using organic and inorganic sources generated statistically significant increases in grain, straw, and biological yields. Similar results were obtained by Sharma and Manohar (2002) Sardana *et al*. (2002), Reddi and Patil (2003) [30] and Stoeva and Tonev (2003).

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