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Response of Wheat (*Triticum aestivum* L.) to Organic manure and Chemical fertilizer

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ABSTRACT

In order to study the impact of organic manure (Farmyard manure, Vermicompost), chemical fertilizer (NPK, Urea) and their combination on the growth, production and quality performance of wheat, an experiment was conducted under field conditions on black cotton soil by using Randomized block design (RBD) with three replications. A total of nine treatments using organic manure, chemical fertilizer and the integrated ones were used in order to find the optimum doses that would be successfully used for the better production and quality of the crop. The various parameters studied during the present investigation were; growth parameters (root length, shoot length, fresh weight, dry weight) which were studied at 15, 30, 45 and 60 days after sowing, yield attributes (number of spikes per plant, number of spikelets per spike, number of grains per spike, length of spike, hundred (100) grain weight) and yield. The results revealed that all the growth parameters were significantly enhanced in all the fertilizer treatments than the control ones and were more in the organic and integrated treatments than the chemical (inorganic) ones. Moreover the yield attributes and yield was significantly improved by the application of organic manure and integrated treatments than the inorganic fertilizers. Vermicompost along with NPK fertilizer registered maximum yield (2917 kg/ha) followed by the separate vermicompost treatment (2886 kg/ha) compared with the minimum yield (1462 kg/ha) observed in control. Among all the fertilizers vermicompost was most effective. The study concluded that application of organic manure (Vermicompost, Farmyard manure) along with NPK fertilizer is more helpful for the enhancement of growth and production of wheat as compared to separate use of organic manure and chemical fertilizer.

Keywords: Vermicompost, Organic manure, Farmyard manure, NPK, Growth, Yield

I INTRODUCTION

Wheat (*Triticum* spp.) evolved from wild grasses and is thought to have first been cultivated between 15,000 and 10,000 BC. It is a tall annual plant with a height ranging from two to four feet. Wheat is grown not only in tropical and sub-tropical zones but also in the temperate zones between 47° S and 57° N latitude from sea level to an elevation of 3,300 metres. In India, its cultivation is spread between 10° N to 37° N latitudes.

Wheat is the most important cereal crop of the family Poaceae. It is highest in the production of all the crops of the world and is grown on more land area than any other commercial food crop. Globally wheat is the leading source of vegetable protein in human food, having higher protein content than other cereal grains. The approximate biochemical composition of wheat is 66-71.6% carbohydrates, 13-16.7% proteins, 2.5-3.1% fats, 2.5-3% crude fibre (Khan, 1984). India stands first in area and second in wheat production next to China in the world. For the year 2015-16 the production of Wheat in China was 128.85 million metric tons while in India it was only 90 million metric tons. Further the productivity of Wheat in Egypt for 2015-16 was 6.43 metric tons per hectare while in India it was only 2.98 metric tons/hectare (Indiastat, 2017).

Wheat being very important crops of India, but its productivity is often limited by the low availability of essential nutrients or imbalanced nutrition, forming one of the important reasons for low productivity of wheat crop in India. Hence a balanced nutrient application is must to harness the productivity of the crop. Among the essential nutrients, macro-nutrients such as, nitrogen, phosphorus and potassium play an important role in improving plant growth and yield. As we know the continues (excess) use of chemical fertilizers are harmful for the plants as well as for the environment. Therefore it is necessary to move towards organic manures which are eco-friendly and are less expensive than chemical fertilizers and can reduce their excess use. In the present study an attempt was made to focus on the use of organic manure as fertilizer and to see the comparative impact of organic manure, chemical fertilizer and their combination on the growth, production and quality of wheat on the black cotton soil.

The presence of dark brown colour and its suitability for growing cotton is the reason that “Black Cotton Soil” is popularly known so. The soil is deficient in nitrogen, phosphoric acid and organic matter but rich in calcium, potash and magnesium. Almost all the land area of Ujjain district of Madhya Pradesh is covered by black cotton soil.

There was significant impact of farmyard manure on the growth, yield attributes and yield of wheat (Golakiya *et al.,* 1990; Sharma, 1992). The application of vermicompost significantly enhanced the growth, yield of wheat and can reduce the urea fertilizer up to 25% (Yousefi and Sadeghi, 2014). Kundu *et al.* (2007) reported that application of farmyard manure along with NPK fertilizer significantly improved the growth and production of wheat. The conjoint application of farmyard manure and NPK fertilizer significantly improved the growth and production of wheat (Dwivedi *et al.,* 2007). Devi *et al.* (2011) reported that integrated application of vermicompost and NPK fertilizer significantly improved the growth, yield attributes and yield of wheat. So taking the above facts under consideration an attempt was made to focus of using organic manure as fertilizer and to see the comparative impact of organic manure, chemical fertilizer and their combination on the growth, production and quality of wheat on the black cotton soil.

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II MATERIAL METHODS

Experimental Details:

The research work was carried out under field conditions at the "Botanical Garden" of Govt. Madhav Science PG College, Ujjain, M.P., by using "Black cotton soil" which was not previously treated with any type of fertilizer or pesticide. The field was prepared upto the depth of 20 cm.

Treatment Details:

The nine treatments each of the size of $1m^2$ are;

T_1 =	Control (no fertilizer)	T_2 =	20% Farmyard manure (FYM)
T_3 =	20% Vermicompost (VC)	T_4 =	200 gm NPK
T_5 =	10% FYM + 100gm NPK	T_6 =	10% VC + 100 gm NPK
T_7 =	200 gm Urea	T_8 =	10 % FYM + 100 gm Urea
T_9 =	10% VC + 100 gm Urea		

Where,

20% of organic manure (VC or FYM) = 20% of the $1m^2$ soil i.e. 20 cm^2 soil up to the depth of 20 cm.

10% of organic manure (VC or FYM) = 10% of the $1m^2$ soil i.e. 10 cm^2 soil up to the depth of 20 cm.

Plant Material: The healthy and certified seeds of Lok-1 cultivar of wheat were used in the present study. About 150 seeds were sown in field trials with three replicates for each treatment in a Randomized Block Design at Govt Madhav Science PG College Ujjain (M. P.). Treatments were given to the soil before sowing of seeds in different concentrations.

Experimental Details

Design	=	Randomized block design.
Replications	=	3(three)
Treatments	=	9 (ten)
Plot size	=	1 m^2

Physico-chemical properties (quality parameters) of the Soil, Vermicompost (VC) and Farmyard manure (FYM);

The various physico-chemical parameters studied in the present study are, pH, Electric Conductivity (EC), Organic carbon (OC), Nitrogen (N), Phosphorus (P), Potassium (K), Zinc (Zn), Copper (Cu), Iron (Fe), Manganese (Mn). The estimation of pH was performed according to the method given by Jackson (1967). Electric Conductivity (EC) was evaluated according to the method proposed by Jackson (1967). Organic carbon (OC) was performed according to the method given by Walkley and Blacks, 1934. Nitrogen (N) content was determined by Kjeldhal method proposed by Johan Kjeldhal (1883). Phosphorus (P), Potassium (K), Zinc (Zn),

Copper (Cu), Iron (Fe) content was performed according to APHA, AWWA, WPCA (1998) and Saxena M.M. (1998): Environmental analysis: Water, Soil and Air. Agro Botanical Publishers, India.

Root length and Shoot length

These parameters were measured every 15th upto 60 days after sowing by using Centimetre scale.

Fresh weight and Dry weight

These were also calculated every 15Th upto 60 days after sowing by using digital balance. Dry weight was measured after drying the plant material in Hot air oven at 70^{o}C for 24 hours.

Yield attributes and Yield

All the yield parameters were studied after the maturation of the crop. Both crops were harvested, bundles were made plot wise and allowed to dry in the plot for 2-3 days. The crop was threshed; grains were collected, dried and properly weighed with the help of electronic, digital balance.

The data regarding yield attributes and yield was statistically analysed by using ANOVA (Analysis of variance) method.

III RESULTS AND DISCUSSION

Physico-chemical parameters of Soil, Vermicompost and Farmyard manure

Results regarding physico-chemical parameters of Soil, Vermicompost and Farmyard manure are given in Table 1. The pH of the field soil samples was recorded as 7.81 while in case of farmyard manure pH was 7.43. However in the vermicompost it was observed 7.14. Electric Conductivity (EC) was found 1.84 ds/m in the vermicompost while it was observed 1.63 ds/m in the farmyard manure. However in case of field soil it was recorded 0.42 ds/m. Organic carbon (OC) was recorded maximum (198.53 g/kg) in the vermicompost followed by 196.46 g/kg in farmyard manure and was found least (5.63 g/kg) in the soil samples.

Nitrogen (N) was observed maximum (246 kg/ha) in case of vermicompost followed by 233 kg/ha in farmyard manure and was least (95kg/ha) found in the soil. The phosphorus (P) content was found more i.e.55.24 kg/ha in the vermicompost than the farmyard manure where it was found 50.16 kg/ha. However it was recorded minimum (7.63 kg/ha) in the soil. Potassium (K) content was recorded maximum (438.52 kg/ha) in vermicompost followed by farmyard manure where it was found 396.37 kg/ha. The least potassium content i.e. 145 kg/ha was recorded in the soil.

Zinc (Zn) content was found maximum (320.13 ppm/ha) in vermicompost followed by farmyard manure where it was found 291.52 ppm/ha. It was observed least (39.47 ppm/ha) in the soil. Maximum copper

(Cu) content i.e. 289.34 ppm/ha was recorded in vermicompost followed by 273.53 ppm/ha in farmyard manure. However copper content was found least (96.24 ppm/ha) in the soil. In vermicompost iron (Fe) content was found 239.24 ppm/ha and was recorded more than the farmyard manure where it was observed 212.34 ppm/ha. It was found minimum (29.26 ppm/ha) in the soil. Manganese (Mn) was found maximum (249.37 ppm/ha) in vermicompost followed by farmyard manure where it was observed 214.15 ppm/ha. Manganese content was recorded minimum (68.31 ppm/ha) in the soil samples.

Table 1: Physico-chemical (quality) parameters of Soil, Farmyard manure and Vermicompost before starting the experiments

Type of Material	pH	EC (ds/m)	OC (g/kg)	N (Kg/ha)	P (kg/ha)	K (kg/ha)	Zn (ppm)	Cu (ppm)	Fe (ppm)	Mn (ppm)
Soil	7.60 ±0.19	0.42 ±0.02	5.63 ±0.34	95.62 ±1.67	7.63 ±0.94	146.53 ±2.45	0.59 ±0.06	3.88 ±0.21	2.87 ±0.13	2.46 ±0.16
Farmyard manure	7.43 ±0.16	1.63 ±0.04	196.46 ±1.13	233.46 ±1.16	50.16 ±1.10	396.37 ±2.64	291.52 ±1.47	273.52 ±1.52	212.34 ±1.44	214.15 ±1.62
Vermicompost	7.14 ±0.12	1.84 ±0.02	198.53 ±0.92	246.57 ±0.85	55.24 ±0.91	438.52 ±2.04	320.13 ±1.16	289.34 ±1.41	239.24 ±1.51	248.37 ±1.24

EC = Electric conductivity, OC = Organic carbon

Vegetative Growth Parameters

Root Length

Results regarding root length of wheat are given in the table 2. The results revealed that at 15 days after sowing, root length was observed maximum (3.6 cm) in 20% VC followed by 20% FYM (3.4 cm), 10% VC + 100 gm NPK (3.3 cm), 10% FYM + 100 gm NPK (3.0 cm), 10% VC + 100 gm urea (2.8 cm), 10% FYM + 100 gm urea (2.6 cm), 200 gm NPK (2.4 cm), 200 gm urea (2.3 cm), while minimum was recorded in control (1.2 cm) treatment. At 30 days after sowing it was found maximum in 20% VC (4.2 cm) followed by 10% VC + 100 gm NPK (3.7 cm), 20% FYM (3.9 cm), 10% FYM + 100 gm NPK (3.5 cm), 10% VC + 100 gm urea (3.4 cm), 200 gm NPK (2.9 cm), 200 gm urea (2.8 cm) and minimum root length was found in control (1.5 cm). However after 45 days of growth it was found maximum in 10% VC + 100 gm NPK (5.5 cm) followed by 20% VC (5.1 cm), 10% VC + 100 gm urea (5.0 cm), 10% FYM + 100 gm NPK (4.8 cm), 20% FYM (4.6 cm), 10% FYM + 100 gm urea (4.3 cm) and minimum (2.1 cm) root length was observed in control. At 60 days after sowing root length was found maximum in 10% VC + 100 gm NPK (7.3 cm) followed by 20% VC (6.7 cm), 10% FYM + 100 gm NPK (6.5 cm), 10% VC + 100 gm urea (6.3 cm), 20% FYM (5.9 cm), 10% FYM +100 gm Urea (5.2 cm), 200 gm NPK (4.4 cm), 200 gm Urea (4.1 cm) and minimum (2.8 cm) in control.

Shoot Length

The results revealed that at 15 days after sowing maximum shoot length (16.2 cm) of wheat was observed in 10% VC + 100 gm urea followed by 200 gm NPK (15.9 cm), 200 gm urea (15.7 cm), 10% VC + 100 gm NPK (14.2 cm), 10% FYM + 100 gm NPK (13.8 cm), 10% FYM + 100 gm urea (13.6 cm), 20% VC (12.5 cm), 20% FYM (12.0 cm) compared with the minimum shoot length (8.2 cm) in control treatment. At 30 days after sowing shoot length was found maximum in 10% VC + 100 gm NPK (19.6 cm) followed by 200 gm urea (19.4 cm), 10% VC + 100 gm urea (19.1 cm), 10% FYM + 100 gm urea (18.7 cm) and minimum (10.2 cm) was in control. However after 45 days it was found maximum in 10% VC + 100 gm NPK (37.3) followed by 10% VC + 100 gm urea (32.7 cm), 20% VC (32.1 cm), and 10% FYM + 100 gm NPK (27.8 cm), 10% FYM + 100 gm urea (26.9 cm), 20% FYM (26.5 cm), 200 gm NPK (25.2 cm), 200 gm NPK (23.5 cm) but minimum shoot length (18.4 cm) was observed in control. Moreover at 60 days after sowing shoot length was recorded maximum in 10% VC + 100 gm NPK (51.1 cm), followed by 10% VC + 100 gm urea (49.2 cm), 20% VC (45.2 cm), 10% FYM + 100 gm NPK (43.7 cm), 20% FYM (42.3), 10% FYM + 100 gm Urea (41.2 cm), 200 gm NPK (37.2 cm), 200 gm Urea (36.4 cm) and minimum (30.2 cm) was observed in control (Table 3).

The results revealed that root length and shoot length increased with the increase in the age of plants. These were observed maximum during early growth stages but after flowering stage there was no significant increase in root and shoot length of wheat.

The results of the present study revealed that the use of combination of organic manure (VC, FYM) and chemical fertilizer (NPK, urea) and chemical fertilizer is beneficial for the root and shoot length of wheat. Vermicompost along with NPK fertilizer is most helpful for the root and shoot growth of plants. It has been suggested that there is need for applying organic manure along with chemical fertilizers, which increase the availability of nutrients considerably resulting in the positive effect on growth parameters (root length, shoot length, fresh weight, dry weight etc) of plants (Babalad, 1999). According to Bachman and Metzger (2008), the hormone-like activity of vermicompost is responsible for the greater root initiation, increased root biomass and enhancement in plant growth. Organic manure (vermicompost, farmyard manure) has high microbial activity due to the majority of microorganisms like bacteria, fungi, yeast, actinomycetes and algae which are responsible for the production of plant growth regulators such as auxins, gibberellins, cytokinins, ethylene and abcisic acid resulting for the better plant growth (Frankenberger and Arshad 1995).

The root length and shoot length of wheat significantly improved by the application of vermicompost (Yousefi and Sadeghi 2014). Sharma *et. al.* (2013) reported that the integrated application of FYM along with NPK fertilizer significantly increased the growth parameters (root length, shoot length etc) of wheat. Sandhya *et al.*, (2014) explored that the use of chemical fertilizer (NPK, urea) improved the growth parameters (root length, shoot length etc) of wheat than the control ones.

Table 2: Root Length of Wheat at different growth stages

Treatment	Root Length (cm)			
	15 Days	30 Days	45 Days	60 Days
Control (T1)	1.2 ±0.94	1.5 ±0.97	2.1 ±0.99	2.8 ±1.13
20% FYM (T2)	3.4 ±0.62	3.9 ±0.67	4.6 ±0.69	5.9 ±0.72
20% VC (T3)	3.6 ±0.51	4.2 ±0.54	5.1 ±0.56	6.7 ±0.59
200 gm NPK (T4)	2.4 ±0.87	2.9 ±0.88	3.7 ±0.94	4.4 ±0.97
10% FYM+100gm NPK (T5)	3.0 ±0.65	3.5 ±0.68	4.8 ±0.70	6.5 ±0.72
10% VC+100gm NPK (T6)	3.3 ±0.43	3.7 ±0.46	5.5 ±0.46	7.3 ±0.49
200gm Urea(T7)	2.3 ±0.89	2.8 ±0.91	3.4 ±0.94	4.1 ±0.97
10% FYM+100gm Urea (T8)	2.6 ±0.68	3.2 ±0.71	4.3 ±0.74	5.2 ±0.77
10% VC+100gm Urea (T9)	2.8 ±0.47	3.4 ±0.53	5.0 ±0.57	6.3 ±0.59

Table 3: Shoot Length of Wheat at different growth stages

Treatment	Shoot Length (cm)			
	15 Days	30 Days	45 Days	60 Days
Control (T1)	8.2 ±1.5	10.2 ±1.92	18.4 ±2.16	30.2 ±2.19
20% FYM (T2)	12.0 ±1.13	16.3 ±1.17	26.5 ±1.19	42.3 ±2.10
20% VC (T3)	12.5 ±0.98	18.4 ±0.97	32.1 ±1.02	45.2 ±1.14
200 gm NPK (T4)	15.9 ±1.36	17.8 ±1.47	25.2 ±1.54	37.2 ±1.57
10% FYM+100gm NPK (T5)	13.8 ±0.97	17.5 ±0.95	27.8 ±1.04	43.7 ±1.16
10% VC+100gm NPK (T6)	14.2 ±0.91	19.6 ±0.95	37.3 ±1.25	51.1 ±1.22
200gm Urea(T7)	15.7 ±1.43	19.4 ±1.48	23.5 ±1.61	36.4 ±1.63
10% FYM+100gm Urea (T8)	13.6 ±1.02	18.7 ±1.13	26.9 ±1.19	41.2 ±1.25
10% VC+100gm Urea (T9)	16.2 ±0.92	19.1 ±0.97	32.7 ±1.24	49.2 ±1.36

Fresh Weight

The results of the present study revealed that fresh weight was found maximum in 200 gm urea (1.92 gm), followed by 10% VC + 100 gm urea (1.80 gm), 10% VC + 100 gm NPK (1.76 gm), 10% FYM + 100 gm NPK (1.62 gm), 10% FYM + 100 gm urea (1.59 gm), 20% VC (1.42 gm), 20% FYM (1.31 gm), 200 gm NPK (1.16 gm), and minimum fresh weight was found in control (0.54 gm) at 15 days after sowing. At 30 days after sowing fresh weight was found maximum in 10% VC + 100 gm NPK (2.79 gm), followed by 10% VC + 100 gm urea (2.64 gm), 200 gm urea (2.25 gm), 20% VC (2.14 gm), 10% FYM + 100 gm NPK (1.96 gm), 10% FYM + 100 gm Urea (1.95 gm), 20% FYM (1.72 gm), 200 gm NPK (1.53 gm)and minimum in control (0.71

gm) treatment. After 45 days it was recorded maximum in 10% VC + 100 gm NPK (4.62 gm) followed by 10% VC + 100 gm urea (4.17 gm), 20% VC (3.90 gm) and minimum in control (1.14 gm). However at 60 days after sowing fresh weight was maximum in 10% VC + 100 gm NPK (5.95 gm) followed by 10% VC + 100 gm urea (5.23 gm), 20% VC (5.13 gm), 10% FYM + 100 gm NPK (4.75 gm), 10% FYM + 100 gm urea (4.31 gm), 20% FYM (4.14 gm), 200 gm NPK (3.62 gm), 200 gm urea (3.58 gm) and minimum (1.87 gm) recorded in 200 gm urea (Table 4).

Dry Weight

The results showed that at 15 days after sowing the maximum dry weight was observed in 10% VC + 100 gm NPK (0.45 gm) followed by 10% VC + 100 gm urea (0.41 gm), 20% VC (0.39 gm), 10% FYM + 100 gm NPK (0.37 gm), 10% FYM + 100 gm urea (0.36 gm), 20% FYM (0.35 gm), 200 gm NPK (0.31 gm), 200 gm urea (0.27 gm) and minimum was observed in control (0.24 gm). At 30 days after sowing it was observed maximum in 10% VC + 100 gm NPK (0.53 gm) followed by 10% VC + 100 gm urea (0.47 gm), 20% VC (0.45 gm), 10% FYM + 100 gm NPK (0.43 gm), 10% FYM + 100 gm urea (0.40 gm), 20% FYM (0.38 gm), 200 gm NPK (0.33 gm), 200 gm urea (0.31 gm) and was minimum in control (0.29 gm). After 45 days it was found maximum in 10% VC + 100 gm NPK (0.59 gm) followed by 20% VC (0.57 gm), 10% VC + 100 gm Urea (0.55 gm), 10% FYM + 100 gm NPK (0.54 gm) and minimum in control (0.31 gm). Moreover at 60 days after sowing dry weight was reported maximum in 10% VC + 100 gm NPK (0.69 gm), followed by 10% VC + 100 gm Urea (0.66 gm), 10% FYM + 100 gm NPK (0.63 gm), 20% VC (0.62 gm), 20% FYM (0.58 gm), 200 gm NPK (0.49 gm), 200 gm urea (0.45 gm) and minimum (0.35 gm) dry weight was observed in control (Table 5).

The experimental results revealed that fresh weight and dry weight was found highest by using vermicompost and integrated use of organic manure and chemical fertilizers. Vermicompost along with chemical fertilizer is more effective than other fertilizers for increasing the fresh weight and dry weight of wheat plants.

The accumulation of carbon and biomass of plant depends upon the formation of organs for nutrient absorption i.e. root and rate of photosynthesis. Important determinants of these organs as well as the photosynthesis rate are the availability of nitrogen, phosphorus, potassium (N, P and K) and other essential nutrient elements. During the early growth stages, the root and shoot development is slow, as a result less dry matter accumulation occurs in the plants. But, during luxurious growth period, these organs are active and resulted in higher dry matter production due to accumulation of photosynthetic products (Mendhe *et al.,* 2002; Lal and Suman 2004). Ganai (1983) and Sharma (1992) reported that the growth parameters (root length, shoot length, fresh weight, dry weight etc) of plants significantly increased by the application of farmyard manure (FYM). There is significant increase in the growth and yield of wheat crop by the application of organic manures (farmyard manure, poultry manure, and vermicompost) in comparison with the use of NPK fertilizer (Ghosh *et al.,* 2003). Patil and Bhilare (2000) reported that application of vermicompost significantly increased

the growth (root length, shoot length, fresh weight, dry weight etc) of wheat. Similar results were also observed in wheat by Karemegam *et al.* (1999) and Mathivanan *et al.*, (2012).

Moreover organic manures help to improve the soil structure which in turn increases the infiltration and retention of water, improves soil aeration and moderates soil temperature and as a result improve the plant growth (Allison, 1973).

Table 4: Fresh weight of Wheat at different growth stages

Treatment	Fresh weight (gm)			
	15 Days	30 Days	45 Days	60 Days
Control (T1)	0.54 ±0.24	0.71 ±0.26	1.14 ±0.22	1.87 ±0.29
20% FYM (T2)	1.31 ±0.30	1.72 ±0.33	2.92 ±0.31	4.14 ±0.35
20% VC (T3)	1.42 ±0.37	2.14 ±0.34	3.90 ±0.36	5.13 ±0.40
200 gm NPK (T4)	1.16 ±0.28	1.53 ±0.34	2.51 ±0.41	3.62 ±0.35
10% FYM+100gm NPK (T5)	1.62 ±0.32	1.96 ±0.37	3.61 ±0.40	4.75 ±0.36
10% VC+100gm NPK (T6)	1.76 ±0.37	2.79 ±0.38	4.62 ±0.43	5.95 ±0.43
200gm Urea(T7)	1.92 ±0.3	2.25 ±0.36	2.94 ±0.41	3.58 ±0.4
10% FYM+100gm Urea (T8)	1.59 ±0.35	1.95 ±0.39	3.26 ±0.37	4.31 ±0.4
10% VC+100gm Urea (T9)	1.80 ±0.35	2.64 ±0.37	4.17 ±0.38	5.23 ±0.41

Table 5: Dry weight of Wheat at different growth stages

Treatment	Dry weight (gm)			
	15 Days	30 Days	45 Days	60 Days
Control (T1)	0.24 ±0.02	0.29 ±0.06	0.31±0.08	0.35 ±0.07
20% FYM (T2)	0.35 ±0.06	0.38 ±0.08	0.53 ±0.09	0.58 ±0.10
20% VC (T3)	0.39 ±0.08	0.45 ±0.06	0.57 ±0.08	0.62 ±0.07
200 gm NPK (T4)	0.31 ±0.06	0.33 ±0.05	0.46 ±0.08	0.49 ±0.08
10% FYM+100gm NPK (T5)	0.37 ±0.08	0.43 ±0.06	0.54 ±0.10	0.63 ±0.12
10% VC+100gm NPK (T6)	0.45 ±0.09	0.53 ±0.10	0.59 ±0.14	0.69 ±0.17
200gm Urea(T7)	0.27 ±0.03	0.31 ±0.06	0.42 ±0.09	0.45 ±0.07
10% FYM+100gm Urea (T8)	0.36 ±0.09	0.40 ±0.13	0.48 ±0.16	0.59 ±0.19
10% VC+100gm Urea (T9)	0.41 ±0.12	0.47 ±0.15	0.55 ±0.19	0.66 ±0.16

Yield Attributes

Number of Spikes per plant

Results regarding the yield attribute and yield of wheat are given in table 6. The maximum number of spikes per plant was recorded in 10% VC + 100 gm NPK (11), 20% VC (9), 10% VC + 100 gm urea (8), 10% FYM +

100 gm NPK (7), 20% FYM (6) 200 gm NPK (5), 10% FYM + 100 gm urea (6), 200 gm urea (5) and minimum was observed in control (4) treatment.

Length of Spike

The results showed that the maximum length of spike was recorded in the treatment of 10% VC + 100 gm NPK (9.2 cm) followed by 20% VC (8.5 cm), 10% VC + 100 gm urea (8.3 cm), 10% FYM + 100 gm NPK (7.7 cm), 10% FYM + 100 gm urea (6.9 cm), 20% FYM (6.4 cm) 200 gm NPK (6.2 cm), 200 gm urea (5.5cm) and minimum was recorded in control (4.4 cm) treatment.

Number of spikelets per spike

The results of the present research revealed that number of spikelets per spike was found highest in 10% VC + 100 gm NPK (43) followed by 20% VC (40), 10% VC + 100 gm urea (39), 10% FYM + 100 gm NPK (34), 20% FYM (32), 10% FYM + 100 gm urea (29), 200 gm NPK (29), 200 gm urea (27) and minimum was recorded in control (18).

Number of grains per spike

The maximum number of grains per spike was found in 10% VC + 100 gm NPK (42) followed by 20% VC (38), 10% VC + 100 gm urea (37), 10% FYM + 100 gm NPK (35), 10% FYM + 100 gm urea (31), 200 gm NPK (26), 200 gm urea (23) and minimum was recorded in control (17) treatment.

Hundred (100) seed weight

The hundred seed weight was recorded maximum in 10% VC + 100 gm NPK (4.75 gm) followed by 20% VC (4.36 gm), 10% FYM + 100 gm NPK (4.25 gm), 10% VC + 100 gm urea (4.18 gm), 20% FYM (4.13 gm), 10% FYM + 100 gm urea (4.06 gm), 200 gm NPK (3.92 gm), 200 gm urea (3.68 gm), and it was observed minimum in control (3.16 gm).

Yield

The results of the present study revealed that the highest yield (production) of wheat was reported in 10% VC + 100 gm NPK (3014.32 kg/ha), followed by 20% VC (2965.49 kg/ha), 10% FYM + 100 gm NPK (2922.81 kg/ha), 10% VC + 100 gm urea (2904.55 kg/ha), 20% FYM (2891.53 kg/ha), 10% FYM + 100 gm urea (2852.43 kg/ha), 200 gm NPK (2704.57 kg/ha), 200 gm urea (2586.24 kg/ha) and minimum yield was observed in control (1528.47 kg/ha) treatment (table 6).

The recorded data regarding the yield attributes and yield of wheat was subjected to statistical analysis to assess the extent of induced variation. Fischer's least significant difference (LSD) test (P value < 0.05) was used to determine the differences in the average values.

The results showed that application of organic manure (VC, FYM), chemical fertilizers (urea, NPK) and their combination improve the yield and yield attributes of wheat crop. Moreover organic manures are more significant than the chemical fertilizers. The integrated use of organic manure (VC, FYM) and chemical fertilizer (NPK, urea) significantly increased the yield of wheat and was more effective than the separate use of organic manure and chemical fertilizer.

The size of sink affects the production and movement of photosynthates in the plants. Therefore any increase in sink capacity is likely to result in higher production and movement of the synthesized carbohydrates which were in excess to metabolic needs of the plant. The higher quantity of dry matter might have been transformed to yield attributes, which in turn increased the grain yield. Moreover the optimum plant growth and development is essential for better quality of yield (Theunissen *et al.*, 2010).

Due to combined application of organic manure and inorganic fertilizer the yield was improved which might be attributed to the slow release of nutrients in the soil resulting in better crop growth and higher yield (Katkar *et al.*, 2011). Ayanaba and Okigbo (1974) explored that because of the slow release of nutrients and favourable conditions by the organic manure application resulting in the enhancement in growth, yield attributes and yield in wheat. Ranjit and Rai (2004) revealed that the availability of nitrogen, phosphorus, potassium and organic carbon content of soil improved by the conjoint application of organic manure and chemical fertilizer, resulting in the enhancement of the use of organic and inorganic nutrient sources for the higher production of crops and maintenance of fertility and quality of the soil. The application of vermicompost along with NPK fertilizer has been reported to increase the dry matter, yield parameters and grain yield (3.6 t/ha) of wheat (Desai, 1999).

In the present study the combined application of organic manure (FYM, vermicompost) along with chemical fertilizer (urea, NPK) helped in improvement of yield limiting factors, which in turn results in better exploitation of yield determining factors and thus resulted in better yields. These findings are in agreement with Ranwa and Singh (1999) in wheat.

The advantage of organic manures to increase the yield of crops is because of their capability to provide essential nutrients other than nitrogen (N), phosphorus (P) and potassium (K). The application of vermicompost and farmyard manure is known to increase the concentrations of iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu). Higher nutrient uptake by the use of inorganic fertilizers might be due to higher nutrient concentration along with higher biomass production (Swarup and Yaduvanshi, 2006). The application of vermicompost along with chemical fertilizer (NPK) significantly enhance the yield attributes and yield of wheat because of the continuous availability of nitrogen, phosphorus and potassium at the early growth stages of crop through chemical fertilizer and at later stages by the slow release of nutrients through organic manure (vermicompost). The application of vermicompost delays leaf senescence and this might be the reason for increased seed weight of plants. The positive impact of the availability of plant nutrients and humic substances (organic acids, etc) from organic manure (vermicompost, farmyard manure) and balanced supplement of nitrogen through chemical fertilizer might have induced cell division, cell wall expansion, meristematic activity, photosynthetic efficiency and regulation of the intake of water into the cells, resulting in the enhancement of yield parameters (Sekar, 2003). The application of organic manure (VC, FYM) along with chemical fertilizer (NPK) enhances the microbial activity (Rani and Srivastava, 1997), increase nutrient use efficiency (Narwal and Chaudhary, 2006) and improves the availability of the native nutrients to the plants resulting in the higher nutrient uptake and maximuim yield of crops (Bhandari *et al.*, 1992).

IV CONCLUSION

For enhancing the growth and production of crops fertilizers whether organic or inorganic play a significant role. Organic manure (vermicompost, farmyard manure) is more helpful than chemical fertilizer (NPK, urea) for the better growth and production of wheat. The conjoint application of organic manure (vermicompost, farmyard manure) and chemical fertilizer (NPK) is more beneficial for the better growth and production of the wheat crop than using them separately. Vermicompost is more nutrient rich than farmyard manure, contains various types of macro and micro-nutrients for the best growth and production of crops. For the better growth and maximum grain yield of wheat the integrated application of vermicompost and NPK is the best fertilizer combination. In the present study by the integrated application of 10% vermicompost along with 100 gm NPK, the productivity (yield) of wheat was increased to 3014.32 Kg per hectare. The productivity was 5.46% more than the state productivity (2849.7 Kg/ha) of Madhya Pradesh and 8.77% more than the national productivity (2749.9 Kg/ha) of India. Therefore it is recommended that there is need to prefer organic manure (VC, FYM) and apply the combined application of organic manure (vermicompost, farmyard manure) and NPK fertilizer instead of using them separately for the best growth, production and quality of the wheat crop.

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