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Effect of organic nutrient sources on growth, yield attributes and yield of wheat under rice (*Oryza sativa* L.) wheat (*Triticum aestivum* L.) cropping system

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Abstract
The investigation was carried out at the Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, (U.P) during Rabi seasons of 2017-18 with three replication. The experiment was laid out in Randomized Block Design (RBD) with seven treatments *viz.* T_1=Control, T_2=10 t ha^{-1} Farmyard manure, T_3=10 t ha^{-1} Farmyard manure + Cow urine +biofertilizer (*Azotobacter*), T_4=10 t ha^{-1} Vermicompost, T_5=10 t ha^{-1} Vermicompost+ Cow urine +biofertilizer (*Azotobacter*), T_6=7.5 t ha^{-1} Farmyard manure + Cow urine +biofertilizer (*Azotobacter*), T_7=80% of RDF of nitrogen through vermicompost + 10% through neem cake + biofertilizer (*Azotobacter*) was laid out in randomized block design with three replication. Result show that T_7 (80% of RDF of nitrogen through vermicompost + 10% through neem cake + *Azotobacter*) significantly higher the growth and yield attributing character of wheat *viz.* plant height(cm), dry matter accumulation(q ha^{-1}), number of tillers (m^{-1})row length, grainsspike^{-1}, grain yield (q ha^{-1}), straw yield (q ha^{-1})and test weight(g) over the control plot. It also recorded significantly higher spike length 67.69% grain yield 70.16%, test weight 52% and harvest index 5% of wheat over control plot. The present study thus indicates that a combination of 80% of RDF of nitrogen through vermicompost + 10% through neem cake + *Azotobacter* (T_7) better use for the cultivation of wheat.

Keywords: FYM, productivity, vermicompost, test weight and jointing stage

Introduction
Agriculture in India is the means of livelihood of almost two thirds of the work force in the country. It has always been India's most important economic sector. Wheat is an important crop in India after rice and India has high production after china. It is belongs to poaceae family and provides 21% of the food calories and 20% of the protein for more than 4.5 billion people in 94 countries. It is a good source of carbohydrates, protein and vitamins in human food, which is relatively higher compared to other major cereals. In 2021, world wheat production was 772.8 million tonne (USDA, 2021) [24]. Wheat flour is used to make "chappati" which is its most common consumable form in country. Animal are fed using wheat straw (ICAR, 2009) [8]. The rice-wheat cropping system is the backbone of India's food security. The magnitude of the contribution of rice-wheat cropping system to the country's food security can be gauged from Punjab alone, which has less than 2% of the country's cultivated land, and provides 60% of the wheat and 40% of the rice to the Public Distribution System and national buffer stocks (Swaminathan, 2007) [23]. The evidence is clear that the soil's native ability to supply sufficient nutrients has decreased with the higher crop productivity levels associated with increased human demand for food. One of the greatest challenges and need of our generation will be to develop and implement soil, crop and nutrient management technologies that enhance the health and quality of the soil, (Gawde *et al.*, 2017) [5]. Numerous studies have shown that manure application to agricultural lands can increase the available soil micro- and macro-nutrients and their concentrations in plant tissues (Nikoli and Matsi, 2011; Gosset *al.*, 2013) [15, 7], improve soil chemical and physical properties and stimulate microbial activity, especially that of earthworms (Jensen, 2013) [10]. Usha and Patra (2003) [25] reported that the use of *Azadirachtin* from neem seed to coat urea is a common practice to reduce nitrogen loss by reducing the activity of nitrifying bacterial.

Neem seed cake is the cheap and easily available nitrogen inhibitors that inhibits nitrification process in soil and improved the N recovery from applied N in arable soil. Cow urine is liquid excreted by cow and contain Water 95%, Urea 2.5% as well as Minerals, Hormones, Salts & Enzymes - 2.5%, (Bhadauria., 2002) [2]. After regular use of cow urine in the crops farmers have found that soil microorganism has increasedalong with the crop production. Which is biodegradable and ecofriendly with good antibacterial action. It is one of the ingredients of "Panchagavya" which is capable of treating many diseases as it has several medicinal properties (Pathak and Kumar, 2003) [16]. It has an excellent germicidal power, antibiotics and antimicrobial activity. Therefore, cow urine can kill varieties of germs. It also source of micro, macronutrients and has disinfectant and prophylactic properties thus purify the atmosphere and improve soil fertility (Pathak and Ram, 2013) [17]. Wheat is the most important winter food crop in India and improvement in its productivity has played a key role in making the country self-sufficient in food grain. However, in the past decade, a general slowdown in further increase in the productivity of wheat has been noticed, which is undesirable with building population pressure. The biofertilizer (*Azotobacter*) application significantly improved growth, grain yield and straw yield of wheat over un-inoculated plots and enhanced the concentration of micro nutrients like Fe, Zn, Cu and Mn. *Azotobactor* supplied additional nitrogen in an eco-friendly manner and plays a vital role in wheat. Hence, *Azotobactorization* has synergistic effect on plant growth and yield attributes. The vermicomposting is bio-oxidation and stabilization of organic material involving the joint action of earthworm and microorganisms. Although, microbes are responsible for the biological degradation of the organic matter, earthworms are the important drivers of the process, conditioning the substrate and altering biological activity (Aira *et al.*, 2002). A positive effect of vermicompost application on growth and productivity of cereals and legumes (Suthar, 2006). Nitrogen is one of the major essential nutrients applied to the crop for higher vegetative growth, productivity and quality (Iqbal *et al*., 2012) [9].

The aim of this field study was to assess the effect of organic nutrient sources on growth, yield attributes and yield of wheat. Organic nutrient sources have an implication on agricultural sustainability because it increases soil fertility and productivity. Farmyard manures, vermicompost, neem cake and bio-fertilizer have a high potential to boost up crop growth. Judicious use of organics nutrients improves soil physical, chemical and biological properties and improves the crop production and productivity (Sharma *et al.*, 2007) [21]. Application of organic manures may also improve availability of native nutrients in soil as well as the efficiency of applied fertilizers (Sawrup, 2010) [19]. Rice (*Oryza sativa* L.) - Wheat (*Triticum aestivum* L.) cropping system is important to meet local food needs and ensure food security. It is India's most prominent and popular dual cropping system under irrigated conditions. Traditionally a monsoon season crop, rice-wheat is still the dominant rice-based system and in India's first major crop rotation. Actually, the philosophy of organic farming is to feed the soil and it is a means of giving back to the nature, what has been taken from it. With a perception that tomorrow's ecology is more important than today's economy. Keeping this information, the present experiment was undertaken to study the effect of organic nutrient sources on growth, yield attributes and yield of wheat under rice-wheat system.

Materials and Methods

A field experiment was conducted during *Rabi* season of 2017-18 at Crop Research Centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The climate of this region is semi-arid and sub-tropical with extremely hot summer and cold winter, minimum and maximum temperature both exhibit a gradual decrease starting from first week of October and reach their minimum in December. The minimum and maximum temperature ranged from 5.8-23.2 ºC and 15.4- 44.5 °C, respectively, with a total rainfall of 91.6 mm received during the cropping season. Wind velocity range 1.2-4.1 km hr^{-1} during experimentation. The trial field has a flat topography with gentle slopes and good drainage. Before the preparatory cultivation of the test area, soil samples were taken from a depth of 0 to 15 cm from 10 spots before the sowing of the wheat crop in the experimental field. The samples thus collected were mixed homogenously, and the composite sample was air-dried, powdered, and allowed to pass through a 2 mm sieve. It was analyzed for different Physico-chemical properties. Soil pH and ECe (1:2.5 soil: water) of saturated paste by glass electrode and extract using solu-bridge conductivity meter, respectively, were measured by the method of Jackson, (1973). The results of the soil analytical data indicated that the experimental soil is Sandy loam in texture (hydrometer method), slightly alkaline in reaction (pH-7.25), low in organic carbon 0.41% (Walkley and Black, 1934), and low available nitrogen 143.0 kg ha^{-1} (Subbiah and Asija, 1956) and medium in available phosphorus 12.7 kg ha^{-1}(Olsen's *et al.*, 1954) and potassium 135.3 kg ha^{-1}(Jackson., 1973) with an electrical conductivity 0.29 dSm^{-1} and soil is categorized in alluvial soil (inceptiosol in the soil taxonomy by USDA). The treatments consisted of a control (no organic manure applied) and seven combinations of organic manures and biofertilisers *viz.* T_1=Control, T_2=10 t ha^{-1} Farmyard manure, T_3=10 t ha^{-1} Farmyard manure +Cow urine +biofertilizer (*Azotobacter*), T_4=10 t ha^{-1} Vermicompost, T_5=10 t ha^{-1} Vermicompost+ Cow urine +biofertilizer (*Azotobacter*), T_6=7.5 t ha^{-1} Farmyard manure + Cow urine +biofertilizer (*Azotobacter*), T_7=80% of RDF of nitrogen through vermicompost + 10% through neem cake + biofertilizer (*Azotobacter*) was laid out in randomized block design (RBD) with three replication. FYM, vermicompost and neem cake were applied one day before sowing as per treatment. Wheat cultivar PBW-590 was sown in rows 20 cm apart on 24 December 2017 and harvested on 16" May 2018. The seeds were inoculated with biofertilizer i.e. *Azotobacter* before sowing as per treatments. The crop received six uniform irrigations (at crown root initiation, tillering, jointing, flowering, milking and dough stages). The height of the five tagged plants was measured at Tillering, Jointing and At harvest in each plot. The height was measured with the help of meter scale from the base of plant to the tip of the tallest leaf up to emergence of spike and thereafter up to tip of spike. Average plant height was computed and expressed as cm. Number of tillers per meter row length were counted at Tillering, Jointing and At harvest. Tillers were reported as number of tillers m^{-1}. For dry matter accumulation plants were harvested from one-meter row length from the various places at Tillering, Jointing and At harvest. The plants were sun dried separately and then oven dried at 72 ± 0.5 ^{0}C till the constant weight is obtained. The values of dry matter accumulation was then computed and expressed in qha^{-1}. Ten spikes of wheat were selected at harvest and their length was measured in centimeter from the base of the spike/ lower spikelet to the tip of the spikelet and mean length of spike was computed. Number of spikelet from ten selected spikes was counted and average was computed. From the ten spikes of wheat, grains were separated, cleaned and counted and the mean value of grains per spikes was computed. Crop harvested at maturity stage and then threshing a random sample of grains was drawn from of each plot. From this sample, 1000-grains were counted at random and their weight (g) was recorded. After harvesting the crop of net area produce was sun dried for one week and then weight of total harvested produce of each plot was recorded and converted into q ha^{-1}.After taking the weight of total biomass, produce of each net plot was threshed separately and clean grains sundried to maintain 12% moisture. The grain yield was recorded in kg plot^{-1} and finally the value was converted into q ha^{-1}.Weight of total produce per net plot was recorded before threshing. The straw yield was calculated by subtracting the grain yield from the weight of total produce of net plot and expressed in quintal per hectare. Harvest index is the ratio between the economic yield and biological yield and calculated by formula as given by Donald (1962). It measures the partitioning of photosynthates towards grains, express seed in percentage and calculated by the formula:

$$\text{Harvest index}(\%) = \frac{\text{Economic yield}}{\text{Biological yeild}} x \; 100$$

Statistical analysis

The experiment was laid out in Randomized Block Design (RBD). Standard Error of Mean in each case and critical difference only for significant issues were calculated at 5% probability levels as under.

$$\text{SEM} = \frac{\sqrt{\text{EMSS}}}{\text{R}}$$

Where,
SEM± = Standard Error of mean
EMSS = Error mean sum of square
R = Number of replication on which the observation is based.

The data obtained would be subjected to statistical analysis as outlined by (Gomez and Gomez, 1984)[6]. The treatment means will be compared using transformed means. The level of significance used in the "F" test was given at 5%. Critical difference values are shown in the table at a 5% significance level, wherever the "F" test was significant at a 5% level.

$$\text{CD} = \frac{\sqrt{2 \text{ X Error mean square}}}{\text{r}} \text{ X t } 0.05$$

Where C
D = Critical difference
R = Number of replications of the factor for which Critical difference is to be calculated.
$t_{0.05}$ = Value of percentage point of 't' distribution for error degree of freedom at 5% level of significance

Results and Discussion

Effect of organic nutrient sources growth parameters

Organic manure contains primary, secondary and micronutrients. Thus, application of manure significantly increased total biomass, number of spikes, spike length and grains per spike in both the years of study (Table 2) which led to a significant increase in grain and straw yield of wheat with organic manure application over the control. The increase in these components seems to have been brought about by higher amount of available water kept the higher turger potential, which leads to higher rate of photosynthesis due to larger opening of stomata for longer period of time. This has also increased for faster cell division and enlargement, which leads to higher growth rate. Similar findings were recorded by Naresh *et al.* (2012) [13]. At tillering stage, the tallest plants (16.5 cm) was recorded in T_7, which was statistically *at par* to T_5, T_3 and T_6 and significantly taller than the remaining treatments. However, the minimum plant height (12.0 cm) was observed under control (T_1), which was significantly lower than the all other treatments. At jointing and harvest stage, maximum plant heights were recorded in T_7, which were statistically *at par* with all treatments, except T_1 and significantly taller than the remaining treatments. While the shortest plants were observed under control which were significantly lower than the all other treatments. The combination of FYM, crop residue, vermicompost and biofertilizer (*Azotobacter*) resulted in highest plant height compared to control observed by Mehra and Singh (2007) [12]. The maximum numbers of tillers per meter row length at all stages were recorded in T_7, which was statistically *at par* toT_5 and significantly higher than the remaining treatments. While, lower number of tillers was noticed in all stages under control. Patil and Bhilare (2000) [18] reported that application of vermicompost prepared from locally available organic materials (wheat straw, press and FYM), application of press mud cake (PMC) 50% + FYM 50% has recorded highest plant height, number of tillers per plant and seed yield in wheat over their individual application. The added beneficial effect of vermicompost was because of vermicompost contains macro and micro nutrients and also improves physico-chemical and biological properties of the soil, which may improves the availability of applied and native nutrients in soil. From the results presented above, it can be revealed that N in combination with vermicompost had more beneficial effect than their individual effect. These findings are similar to that reported by Shekhon *et al.* (2011) [20]. At tillering stage of wheat, the highest dry matter accumulation (12.3 q ha^{-1}), recorded in T_7, which was significantly higher than the remaining treatments. At jointing stage the maximum dry matter accumulation (44.4 q ha^{-1}) was found in T_7, which was statistically *at par* to T_4, T_5, T_6 and T_3 and significantly higher than the remaining treatments. The minimum dry matter accumulation (38.1q ha^{-1}) was recorded in T_1, which was significantly lower than the remaining treatments. At harvest stage of wheat, the DMA (127.9 q ha^{-1}), was recorded in T_7, which was statistically *at par* to T_3, T_4, T_5 and T_6, but significantly higher than the remaining treatments. The increase in dry matter accumulation under T_7 treatment was mainly due to better growth attributes and plant height and tillers with increased cell division, enlargement, and photosynthesis and protein synthesis. This may also be related to nutrient status of soil to the application of organic manures, which was responsible for maintaining higher levels of chlorophyll content in wheat leaves and thereby, leading to higher photosynthesis and dry matter accumulation by plants. These result concluded by Nehra *et al*., (2001) [14].

Effect on Yield attributes

Adopting a plan for applying farmyard manure, biofertilizer (*Azotobacter*) and Vermicompost (organic sources), neem seed to agricultural soils and cow urine spray on the crop in the context of a sustainable production strategy requires information regarding the effect of organic agriculture sources on wheat crops (Table 1). The maximum spike length and grains per spike recorded with application of80% of RDF of nitrogen through vermicompost + 20% through neem cake + 10% *Azotobacter* (T_7) was statistically *at par* to T_5, T_3 and significantly higher than the remaining treatments. The increase in yield attributes under these treatments might be due to better supply of nutrients besides increase in photosynthetic area, higher photosynthetic activity and more translocation of photosynthesis towards sink. The maximum numbers of grains per spike (44) was recorded in T_7, which was statistically *at par* to T_5 and T_3 but significantly superior than the remaining treatments. The minimum numbers of grains per spike (30) was found in control (Table 1). The increment of yield under these treatments may be production of new cells by better growth performance and favorable source sink relationship. Behera *et al.* (2009) [1] reported that the application of available organic sources, particularly FYM and poultry manure along with the full recommended dose of mineral fertilisers to wheat was essential for improving productivity of wheat-soybean system. Applying higher quantities of organic nutrient at basal dose accumulate more dry matter and increase the vegetative growth compared to other splits. The similar result was reported by Singh and Singh (2005) [12]. The application of organic manures improved the yield – attributing characters, grain and biological yields compared to no organic manure. Higher biological yield was mainly due to combined effect of grains and straw. Similar results were also reported by Kumar *et al.* (2015) [11]. Test weight known as 1000- grains weight (g) ranged from 43.4 to 28.4 g. Maximum test weight 43.4 g statistically at par with all treatments except T_1 and significantly higher than the remaining treatments was found in T_7 while minimum test weight 28.4 g was observed under control which was significantly lower than all other remaining treatment. The highest grain yield (38.61 q ha^{-1}) which was statistically *at par* to T_4, T_5, T_6 and T_3 and significantly higher than the remaining treatments. The significantly lowest grain yield (22.69 q ha^{-1}) was recorded in control. The maximum straw yield (63.70 q ha^{-1}) was recorded in T_7, which was statistically *at par* to T_4, T_5, T_6 and T_3 significantly higher than the remaining treatments. The minimum straw yield (37.43 q ha^{-1}) was recorded in T_1. Biological yield (grain + straw) in wheat under various treatments ranged from 60.12 to 102.31 q ha^{-1}. The maximum Biological yield (102.31 q ha^{-1}), was recorded in T_7, which was statistically *at par* to T_6, T_4, T_5 and T_3 but significantly higher than the remaining treatments. The minimum biological yield of 60.12 q ha^{-1} was found under control plot. These findings were similar to those reported by Billore *et al.* (2009) [3], Duhan *et al.* (2011) [4] and Shekhon *et al.* (2011) [20] Harvest index, which is a ratio of grain yield to biological yield, The maximum harvest index 39, which was non- significant effect between the all treatments and higher than the remaining treatments was found in T_7. Higher harvest index indicate more translocation of photosynthesis from grain leaves towards sink. Grain by improving the yield attributes and yields, in which nitrogen plays a vital role. Similar opinions were also made by Youseftabar *et al*. (2012).

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Table 1: Effect of organic nutrient sources on growth, yield attributes and yield of wheat

	yield attributes						
Treatments	Spike length (cm)	Number of grains spike^{-1}	1000- grains weight (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
T_1	6.5	30	28.4	22.69	37.43	60.12	37.0
T_2	9.2	40	39.6	34.50	56.92	91.42	38.0
T_3	10.2	39	42.6	37.45	61.79	99.24	38.0
T_4	9.4	41	40.7	35.70	58.90	94.6	38.0
T_5	10.6	43	43.1	37.82	62.40	100.22	39.0
T_6	9.8	38	41.3	36.96	60.98	97.94	38.0
T_7	10.9	44	43.4	38.61	63.70	102.31	39.0
S.Em±	0.3	1.3	1.3	1.43	2.36	3.79	1.24
CD (P=0.05)	0.9	3.8	3.8	4.22	6.96	11.20	NS

Table 2: Effect of organic nutrient sources on growth parameter at different stage.

	Plant height (cm)			Number of tillers m^{-1} row length			Dry matter accumulation (q ha^{-1})		
Treatments	Tillering	Jointing	At harvest	Tillering	Jointing	At harvest	Tillering	Jointing	At harvest
T_1	12.0	35.0	57.3	65.0	72.4	60.0	9.3	38.1	75.2
T_2	14.8	53.6	82.5	71.0	83.3	69.0	10.0	39.8	114.3
T_3	15.4	55.8	84.8	79.1	84.6	77.4	10.7	42.7	124.1
T_4	15.0	54.8	83.1	72.0	80.08	70.6	10.1	40.7	118.2
T_5	15.9	57.8	86.6	83.6	88.5	82.7	11.2	43.2	125.3

T_6	15.2	55.5	83.9	75.3	82.7	72.2	10.5	42.3	122.4
T_7	16.5	58.6	87.4	86.4	90.6	84.0	12.3	44.4	127.9
S.Em±	0.5	1.7	2.6	2.5	2.7	2.4	***0.3***	***1.3***	***3.8***
CD (P=0.05)	1.4	5.1	7.8	7.2	7.9	7.0	***1.0***	***4.0***	***11.2***

Author Contributions

Lali Jat and Atin Kumar were responsible for data collection, statistical analysis, interpretation of results and manuscript preparation. Manish Yadav, Basta ram and Dr. B. L. dudwal were involved in manuscript preparation and editing.

Conflict of Interest

The authors have not declared any conflict of interest.

Conclusion

Significant improvement in growth parameters *viz.* plant height (cm), dry matter accumulation (q ha^{-1}), yield attributes and yields were also recorded under T_7 Treatment. Whereas lower recorded in control (no use of organic manure). The present study thus indicates that a combination of 80% of RDF of nitrogen through vermicompost + 10% through neem cake + *Azotobacter* (T_7) better use for the cultivation of wheat.

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