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CONTENTS

Effect of subsurface placement of vermicompost manure on growth and yield of wheat (*Triticum aestivum* L. Var. UP 2526)

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ABSTRACT: To study the impact of the subsurface placement of vermicompost manure on the root density, growth and yield of wheat (*Triticum aestivum* L. Var. UP 2526) the most important cereal crop in the Northern region of India, an experiment was conducted under field conditions in Mollisols soil at Honey Bee Research and Training Centre, G. B. Pant University of Agriculture and Technology Pantnagar by using Tractor Drawn Subsurface Manure and Seed Applicator which was designed in Farm Machinery and Power Engineering Department of the University. An experiment was conducted with five different treatments by the subsurface manure applicator machine on the field at different exposure lengths of rectangular orifice of manure hopper *viz*., control, ¼th, ½nd ¾ th and full opening position. The exposure length of fluted roller seed metering device of the machine was fixed at 1/2nd opening position by a seed rate adjustable lever under all treatments for different forward speeds *viz.,* 2, 4 and 6 km/h and the vermicompost having 31 % moisture content (d.b) was used in all treatments. The depth of placement of wheat was fixed 50 mm by tractor automatic draft and position control lever. The treatment T1 (100 % RDN) showed the best results due to providing maximum plant height, leaf area index, root length and yield of wheat crop. Thus, subsurface application of vermicompost is recommended for higher wheat production. Subsurface placement of vermicompost by the machine resulted in thrice benefits by increasing the wheat yield as well as reducing the application rate of vermicompost per hectare in the field and reducing the labour requirement.

Key words: Applicator, manure, roots density, subsurface, vermicompost, yield

The fertilizers consumption is increasing every year to restore soil fertility and to meet the food grains requirements of the ever-increasing population. In India, the total consumption of nutrients in the form of fertilizers has increased from 65 thousand tonnes in 1951-52 to 29.3 million tonnes in 2019-20. Undoubtedly, the judicious use of these fertilizers and other chemicals increases the agricultural production but poor management may lead to environmental pollution problems. Wheat (*Triticum aestivum* L.) is a very important cereal crop grown in the rabi season in India, cultivated in almost all the countries of the world. Among major wheat-producing countries, India ranked second next to China with regards to its production in the world (agriculture sectors national portal). Wheat is the second most important cereal crop after rice in India and is cultivated under diverse agro-climatic conditions zone. In India, the area under wheat crop was 31.45 million hectares with a production of 107.59 million tonnes having an average yield of 34.21q/ha. Productivity of wheat is low due to less availability of essential nutrients or partially availability of nutrients applied by chemical fertilizer which not only reduced the soil fertility but also very harmful for the plant growth and yield as well as adversely affected the environment. Therefore, it is now important to move towards organic manures which are environmentally friendly and less expensive than chemical fertilizers. The present research has ultimately a goal to prominence on the application of vermicompost manure into the subsurface of soil and to see the impact of organic manure on the growth, production and yield of wheat in mollisols. There was a significant impact of vermicompost manure on the growth, yield attributes and yield of wheat (Golakiya *et al.,* 1990; Sharma, 1992). The applications of vermicompost significantly improved the growth, yield of wheat and reduce the need of the urea fertilizer up to 25 % (Yousefi and Sadeghi, 2014). Kundu *et al*. (2007) reported that the application of farmyard manure along with NPK fertilizer significantly improved the growth and production of wheat. Taking the above facts under consideration an attempt was made to focus on using organic manure as fertilizer and to see the comparative impact of organic manure on the growth, production and quality of wheat in Mollisols.

MATERIALS AND METHODS

Experimental details

The experiment was conducted at Honeybee Research and Training Centre, G.B. Pant University of Agriculture & Technology, Pantnagar, Uttarakhand in the year 2020-21 located in Tarai Region of Uttarakhand. The geographical location of the field was 29.0^0 latitude and 79.47^0 longitudes and at an elevation of 243.0 m from mean sea level. The field was prepared up to the depth of 200 mm.

Physico-chemical properties of soil and vermicompost

To assess the nutrient status of soil, five randomly selected samples from 0-200 mm depth of the experimental field were collected and reduced to a

Table 1: Detail of experimental design and treatments

S. No.	Attributes	Description
1	Statistical Design	RCBD
2	**No of treatments**	
a	T1	100 % RDN through vermicompost by manure applicator
b	T2	75 % RDN through vermicompost by manure applicator
c	T3	50 % RDN through vermicompost by manure applicator
d	T4	25 % RDN through vermicompost by manure applicator
e	T5	Control (no manure)
f	Field size	66 ×39 m
g	Size of one plot	66 × 7.2 m (five in number)
h	No of samples collected	6 samples per treatment
i	Sample size	66 × 1.2 m
j	Bund width	500 mm
k	Total no of replication per treatment	6
l	No of sample taken per speed/ treatment	2 (total six for three forward speeds)
3	**Crop Detail**	
a	Experiment crop	Wheat
b	Wheat variety	UP2526
c	Row to row spacing	200 mm
d	Seed rate	100-125 kg/ha
e	Depth of sowing	50 mm
4	Depth of manure placement	100 mm
5	Organic manure (vermicompost)	7.5t/ha

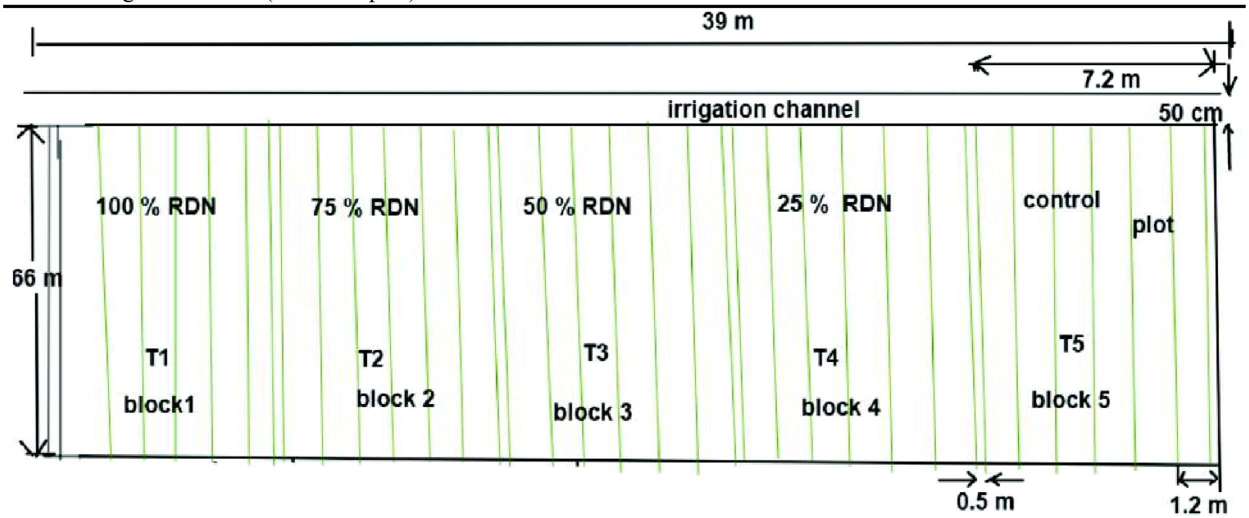


Plate 1: Detail layout of experimental field

Plate 2: Experimental site at *Honey Bee Research* and Training Centre for sowing of wheat

Plate 3: Field performance evaluation of prototype subsurface manure and seed applicator for sowing wheat

composite sample for mechanical and chemical analysis. The soil of the experimental field was classified as Mollisols (grassland soils) which is locally known as Tarai soils. This soil contains large humus content assumed to be most productive soils of the world. The surface layer of these soils is dark in colour. They are soft, even dry, with a granular or crumbly texture.

Crop Parameters

The following parameters were measured in the field are given below.

Number of tiller (m^2)

Numbers of tiller were counted by using a one square meter area frame in each treatment at 30, 60 and 90 DAS. Five replications were taken in each treatment.

Plant height

The height of the randomly selected tillers were measured from five tagged plants from the base of the plant to the highest terminal point/node by a meter tape in one square meter area in each treatment. An average of five plants readings were taken to compute the mean height of wheat plant at 30, 60, 90 DAS and at harvest time.

Leaf Area Index (LAI)

Leaf area index was measured with mobile app Viticanopy in each treatment. Five replications per treatment were taken to find out an average leaf area index of wheat plant at 30, 60 and 90 DAS.

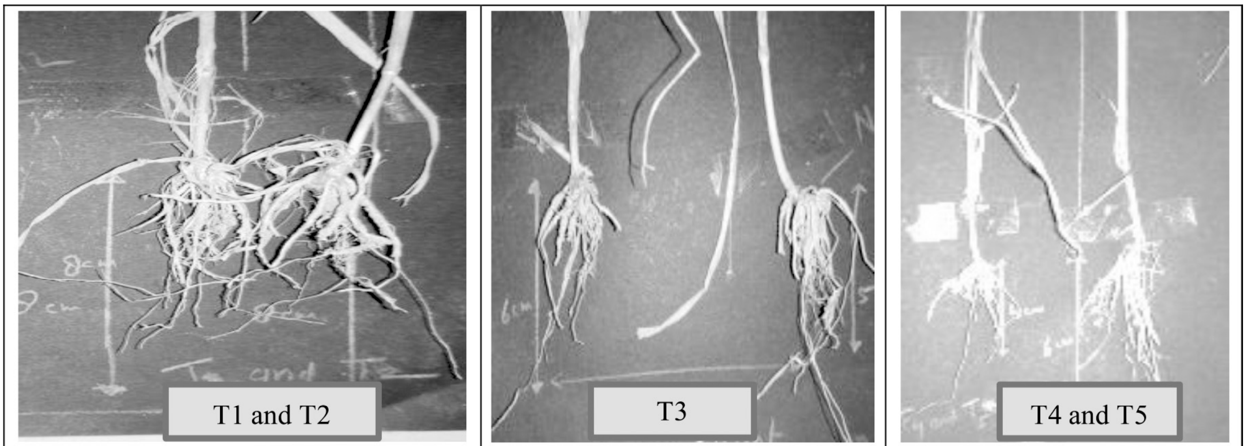
Root length

The root length was measured every 15^{th} up to 60 days after sowing was being measured. Six selected plants from each treatment were uprooted, washed and their root length was measured with the help of a measuring scale. It was measured in centimeter.

Table 2: Physico-chemical properties of soil and vermicompost before starting experiments

Sl. No.	Particular	Unit	Soil Value	Vermicompost Value
1	Soil pH	-	8.2	7.14
2	Electrical conductivity	dS/m	1.4	1.84
3	Organic matter	%	0.88	1.98
Major nutrients				
4	Nitrogen	%	-	2.46
5	Phosphorus	%	110.5	0.55
6	Potassium	%	118.0	4.38
Micro nutrients				
7	Sulphur	ppm	31.88	-
8	Zinc	ppm	0.173	3.20
9	Boron	ppm	0.56	
10	Iron	ppm	13.29	2.39
11	Magnesium	ppm	6.12	2.48
12	Copper	ppm	1.12	2.89

(**Source:** Uttarakhand soil testing laboratory, Rudrapur Uttarakhand)



A.T1 and T2 treatments | **B.**T3 treatment | **C.**T4 and T5 treatment

→ Decreasing Root Growth

Plate 4: Influence of vermicompost subsurface placement on root growth of wheat crop

A:Plant population after 30 DAS

B: Plant population after 60 DAS (flowering stage)

C: Plant population at 90 DAS

D: Plant population at harvest

Plate 3: Plant population measurement at different growth stages

A. Measurement of plant height at 30 DAS **B.** Measurement of plant height at 60 DAS **C.** Measurement of plant height at 90 DAS

Plate.5: Measurement of plant height at different growth stages

Table 3: **Effect of vermicompost manure on plant population, plant height and leaf area index of wheat plants**

Plant population/m^2

Treatment	Orifice opening position of machine	30 DAS	60 DAS	90 DAS	At harvest	Mean	SD	SE
T1	[full]	126.00	434.00	386.50	358.25	326.18	137.06	68.53
T2	[$3/4^{th}$]	128.00	437.25	375.50	359.75	325.12	135.60	67.80
T3	$1/2^{nd}$]	121.00	379.00	372.00	339.25	302.81	122.44	61.22
T4	[$1/4^{th}$]	112.50	330.75	325.75	301.25	267.56	104.17	52.08
T5	[control]	103.25	283.50	274.75	246.65	227.03	84.00	42.00

Plant height, cm

Treatment	Orifice opening position of machine	30 DAS	60 DAS	90 DAS	At harvest	Mean	SD	SE
T1	[full]	15.43	53.02	60.56	62.30	47.82	21.97	10.95
T2	[$3/4^{th}$]	15.10	51.33	58.43	61.83	46.67	21.49	10.74
T3	$1/2^{nd}$]	14.60	50.35	58.46	58.95	45.59	21.04	10.52
T4	[$1/4^{th}$]	14.30	43.75	56.37	53.85	42.06	19.29	9.64
T5	[control]	12.33	35.42	53.68	51.18	38.15	19.01	9.50

Leaf Area Index

Treatment	Orifice opening position of machine	30 DAS	60 DAS	90 DAS	Mean	SD	SE	CV, %
T1	[full]	1.12	2.76	4.62	2.83	1.75	1.01	61.80
T2	[$3/4^{th}$]	1.14	2.69	4.61	2.81	1.73	1.00	61.62
T3	$1/2^{nd}$]	1.11	2.67	4.55	2.77	1.72	0.99	62.03
T4	[$1/4^{th}$]	1.04	2.59	4.50	2.71	1.72	0.99	63.75
T5	[control]	0.94	2.55	4.40	2.63	1.72	0.99	65.68

Yield attributes

Number of spikes

Five spikes were selected randomly from each plot and number of filled grains per five panicles was counted and average number of grains per panicles was worked out.

Spike length

Five spikes were selected randomly and their length was measured. The data of all five spikes were added

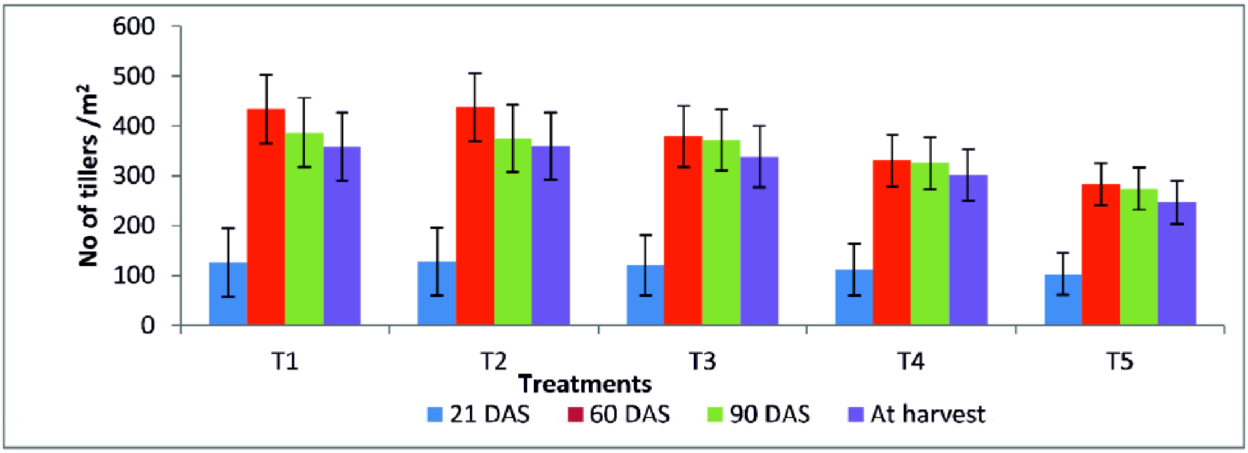


Fig.1: Effect of different treatments on number of tillers of wheat

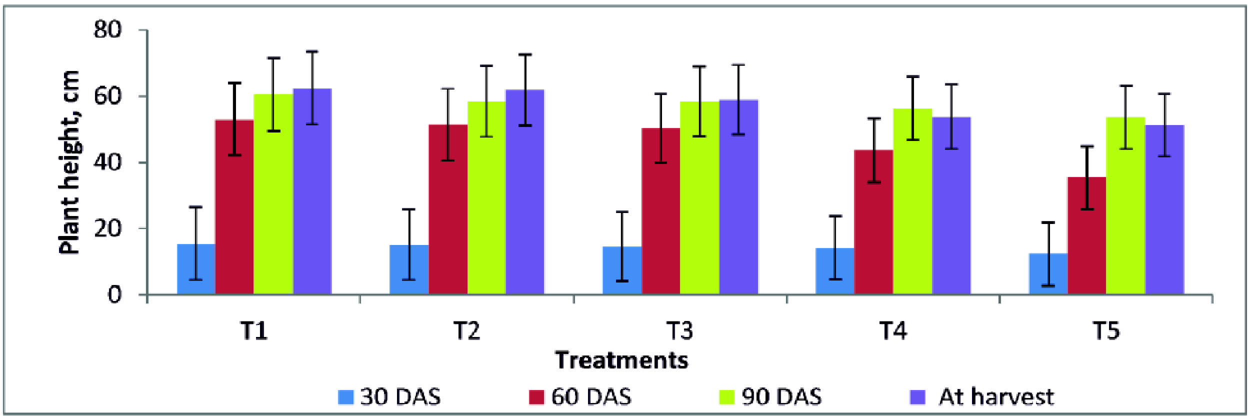


Fig. 2: Effect of different treatments on plant height of wheat

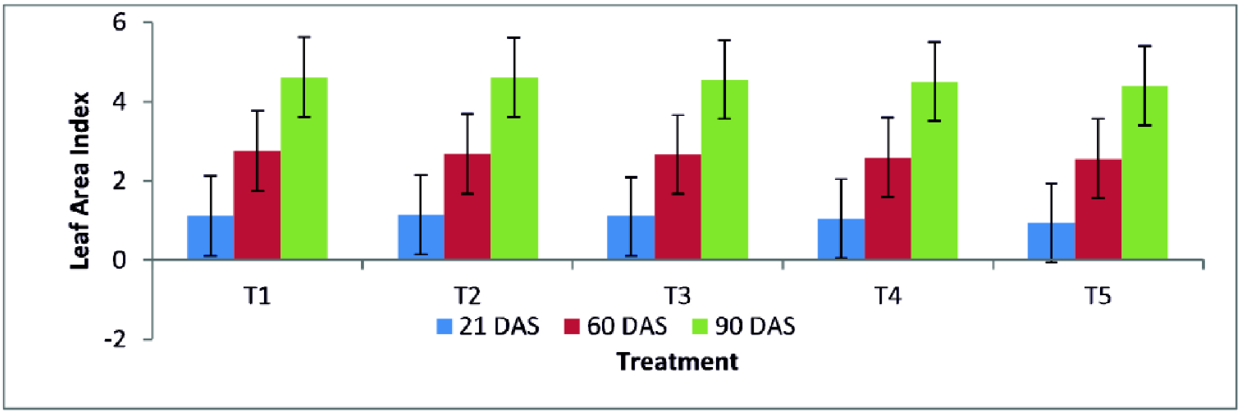


Fig. 3 Leaf Area Index at different growth states of wheat

and the sum was divided by five to get average spike length. It was recorded in cm.

Spikelets per spike

Five spikes were collected randomly in each treatment from each plot, their spikelets were counted and average was worked out.

Grain spike

Five spikes were selected randomly in each treatment

Plate 6: Measurement of spike length and spikelet length

Table 4: Yield attributes of wheat crop

Treatment	Spike length (cm)	Root length (cm)				Spikelet's/ spike	Grain per spike	Test weight, (g)
		15 Days	30 Days	45 Days	60 Days			
T1	9.2	3.6 ±0.51	4.2±0.54	5.1±0.56	6.7±0.59	20.80	51.60	41.90
T2	9.1	3.4 ±0.62	3.9±0.67	4.6±0.69	5.9±0.72	17.20	45.13	40.40
T3	8.6	3.0±0.65	3.5±0.69	4.8±0.70	5.2±0.77	18.00	44.43	38.50
T4	7.8	2.6±0.68	3.2±0.71	4.3±0.74	5.2±0.77	15.90	39.50	37.30
T5	7.5	2.3±0.89	2.8±0.90	3.4±0.94	4.1±0.97	13.90	37.03	32.60

from each plot and filled grain per five spikes were counted and average of counted the number of filled grains per spike was counted. The average of five readings was worked out.

Thousand grain weight (test weight)
One thousand grains from the produce of the net plots were counted and their weight was recorded in grams in each treatment.

Harvesting
All the yield parameters were studied after the maturation of the crop. At mature condition, wheat was harvested and formed small bundles were plot wise and sundried for 3 to 4 days. The grains were threshed using a self-propelled electric thresher. Grain yields of wheat were reported at 12 % moisture content. Straw weight was determined after sun drying.

Grain yield
The produce of net plots was threshed and grain thus obtained individually from each treatment was weighted. The yield recorded in kg/ha would be standardized to 12 % M.C (d.b.). It is measured in kg/ha.

Straw yield
Dry weight of straw collected from each plot was recorded individually for each treatment after sun drying for 3-4 days and expressed in kg/ha.

Biological yield
The produce excluding root mass of each net plot was allowed to sun dry after harvest and weighted to record biological yield (grain + straw) per plot per treatment and measured in kg/ha.

Harvest Index
Harvest index is the ratio of economic yield to the biological yield and it was calculated by using the formula given below.

$$\text{Harvest index} = \frac{\text{Economic yield (kgha}^{-1})}{\text{Biological yield (kgha}^{-1})} \times 100 \quad \textbf{[1]}$$

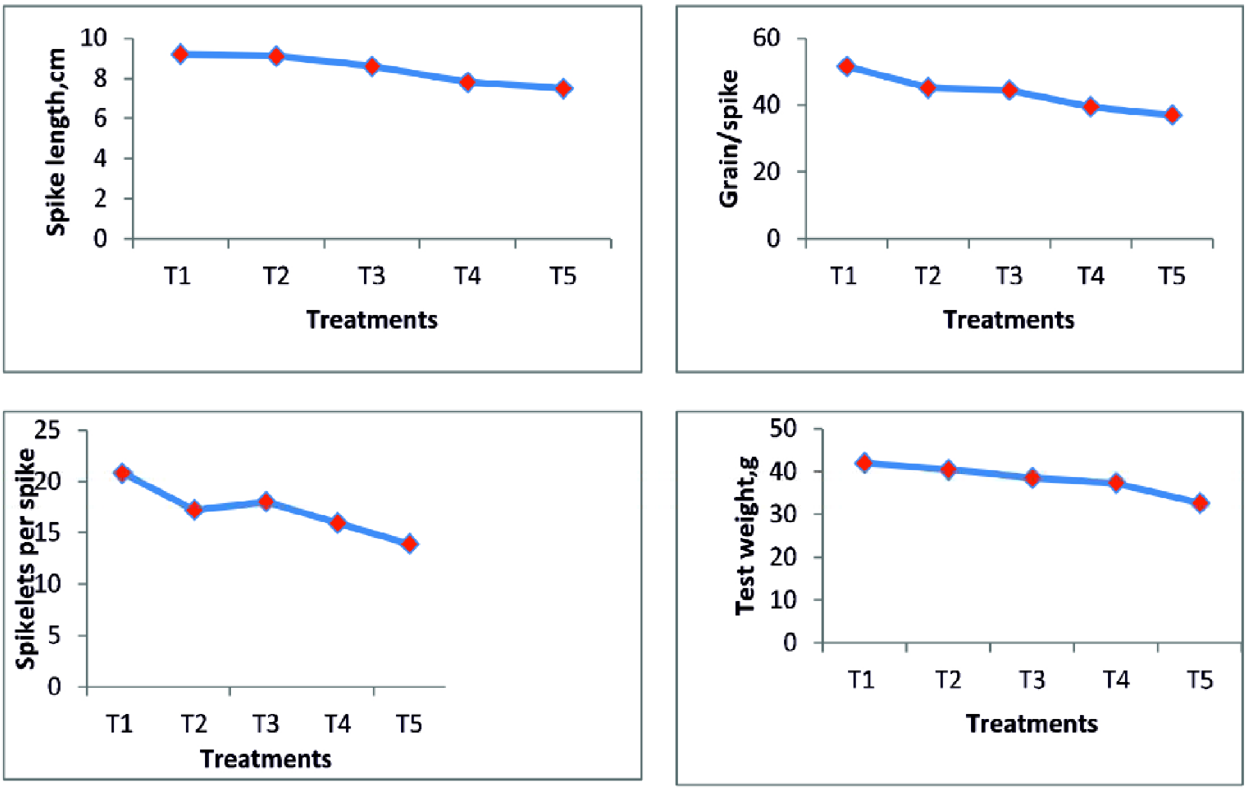


Fig 4: Effect of different treatments on spike length, grain per spike, spikelets per spike and test weight of wheat

Table 5: Effect of different treatments on grain yield, straw yield, biological yield and harvest index of wheat crops

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest Index (%)
T1	1951.30	2121.73	4073.03	47.90
T2	1706.77	1827.80	3537.04	48.27
T3	1341.21	1474.59	2815.80	47.61
T4	975.65	1059.63	2035.28	47.90
T5	607.62	632.32	1242.41	49.00

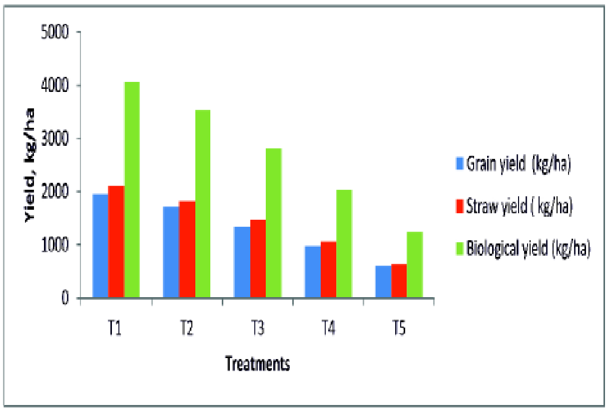


Fig 5: Effect of different treatments on grain, straw and biological yield of wheat

RESULTS AND DISCUSSION

Crop Parameters

Tiller/m^2

Tillers count per unit area is a very important factor for detecting the effect of any treatment on the growth and yield of a wheat crop. The mean data of number of tillers were counted at time interval of 30, 60, 90 DAS and harvest time is presented in Table 3 and illustrated in Fig.1 and the data was statistically analyzed showed that the effect of different treatments was significantly affected (PÂ0.05) on the growth of plants population**.**

Plant height

Plant height was recorded periodically at 30, 60 90 DAS and the harvest stage of the wheat and presented in Table 3. It is evident that the maximum plant height was found in treatment T1 (15.43 to 62.30 cm) at 30 DAS to harvest time when 100% of RDN was applied. The lowest plant height was found in treatment T5 (12.33 to 51.18 cm) (control condition) but the variations among the treatments were found to be non-significant at 30 DAS, 60 DAS and harvest but significantly affected at 90 DAS. Wheat plants attained their maximum height during the early growth period and thereafter, a slow rate of variation in increment in plant height was found during the study.

Leaf area index

The data was pertaining to leaf area index at various stages of growth of wheat plant was measured with the help of mobile app VitiCanopy. The data obtained are presented in Table 3. It was measured at 30, 60 and 90 DAS (days after sowing). The result revealed that the leaf area index was found maximum in treatment T1 and increased from (1.12 to 4.62) while it was found minimum in case of treatment T5 and increased from (0.9 to 4.40).

Root length

The observations in respect of plant roots in different treatments at harvest are presented in Table 4. The visuals of roots of different treatments at harvest are shown in plate 4. It is clear from Table 4 that the application rate of vermicompost had a significant effect on the root length of the wheat crop. The data revealed that the root length was maximum in the case of T1 and T2 treatments respectively whereas the minimum root length was found in case of T4 and T5 treatment.

The result emphasized that root length increased with an increase in the age of plants. These were noted maximum during early growth levels but after the flowering stage there was no significant increase in root length.

Yield Attributes

Spike length

Spike length is directly related to the number of spikelet and grains per spike and hence this is an important parameter to determine grain yield. Spike length may also serve as one of the methods for evaluating the grain production in cereal crops. The average data is presented in Table 4. From the data it was found that the treatment T1 significantly attained the maximum spike length of 92 mm and the least spike length was found in treatment T5 (75 mm). The data is statistically analyzed and it was found that the variations among the treatments were significantly affected the spike length.

Spikelet per spike

From the data, it was found that spikelet's per spike was found significantly maximum in case of treatment T1 of (20.80) and the least spikelet per spike data was found in case of the T5 (13.9) respectively during the experimentation. The data were statistically analyzed and it was found that the effect of different treatments on spikelets per spike was found to be significant.

Grain per spike

The grain per spike was found significantly maximum for the treatment T1 (51.6) but the least grain per spike was found in case of T5 (37.03). The data were statistically analyzed and it was found that the effect of different treatments on grain per spike was found to be non-significant.

Test weight

The average value of test weight of different treatments was presented in Table 4. It was evident from the data that the maximum test weight was found to be 41.9 g in case of treatment T1 followed by T2 (40.4g), T3 (38.5g) and T4 (37.3 g) and least value of test weight was obtained in case of treatment T5 (32.06 g) respectively. The data were statistically analyzed and it was found that the effect of different treatments was significantly affected the grain test weight.

Harvesting

The wheat crop was harvested manually with the help of a sickle tool which cut the crop nearest to the ground surface. Five bundles from each treatment were made of 1kg, 1.5kg, 2.0 kg, 2.5 and 3 kg. Total of 25 bundles were selected for threshing operation and different treatments harvested wheat crop had feed into the thresher to determine the grain yield obtained in individual treatments.

Grain yield

The data related to grain yield of wheat crop in different treatments at harvest were presented in Table 5. It was found that the grain yield was obtained maximum in case of the treatment T1 (1951.3 kg/ha) and the least grain yield obtained in case of T5 (607.62 kg/ha).

Straw yield

The straw yield was obtained after threshing the wheat crop of different treatments. The data obtained after threshing was mentioned in Table 5. Data collected for the different treatments were revealed that the maximum straw yield was obtained in case of treatment T1 (2121.73 kg/ha) and the minimum value of straw yield was obtained in case of T5.

Biological yield

The biological yield of wheat crop was measured by adding the grain yield and straw yield of the different treatments. The biological yield was obtained maximum in case of treatment T1 and the least value obtained in case of treatment T5, respectively.

Harvest Index

The data revealed that the harvest index was maximum in case of the treatment T5 (49 %) followed by T2 and the least value was obtained in case of treatment T3.

CONCLUSION

Vermicompost manure plays a significant role in improving the growth as well as quality of crop. Nearly 70 % of global ammonia emissions are related to ammonia containing fertilizers which are broadcasting over the surface of field. Therefore, subsurface placement of vermicompost manure by subsurface manure applicator machine reduces the ammonia volatilization losses into the atmosphere and diffused it over greater distances. This machine is first time developed in India to subsurface placement of vermicompost manure along with wheat seed. It reduces the labour requirement during field operation. In present study it was found that the maximum yield per hectares of manure (organic) wheat was found to be 1951.3 kg/ha in treatment T1 (100%RDN) while the average yield of conventional wheat was nearly 3421kg/ha (Directorate of Economics and Statistics, 2019-20). Although the yield per hectare was found lesser in organic manure wheat but cost and quality wise both were found high and much better than inorganic fertilizer wheat. The following conclusions drawn-out in the present study were pointed out with response of the developed machine were given below.

1. Significantly highest plant population (358.25) per square meter area, plant height (623 mm), leaf area index (4.62) and root length were found maximum in treatment T1(100%RDN).
2. Significantly grain attributes *viz*. spike length (92 mm), root length (80 mm), spikelets/ spike (20.80), and grain per spike (51.6) and test weight (41.9 g) were found maximum in treatment T1(100%RDN).
3. Significantly higher grain yield (1951kg/ha), straw yield (2124 kg/ha) and biological yield (4075 kg/ha) were found maximum in T1(100%RDN) treatment whereas the harvest Index was found maximum in case of T5 while minimum in T1 treatments.

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