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Effect of neem (*Azadirachta indica* L.), mustard (*Brassica juncea*) de-oiled seed cake and bio-fertilizer on the growth and yield of wheat (*Triticum aestivum* L.)

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Abstract
With “green-mindedness” increasing in popularity, the use of organic substrates has become more important in the retail Organic Agriculture. Yield of wheat is reduced due to limited water availability, poor soil fertility and low organic matter contents in the soil. This study comprised of field experiment on the use of organic amendments for growing wheat HD 3086 (Pusa Gautami) to find out their impact on crop growth, yield, and productivity. First experiment compared the efficiency of various organic manures applied solely and in different combination treatments of the chosen manures on loamy sand soil of the organic farm. The organic matters used in the experiment were: Azotobacter, Farm Yard Manure (FYM), Mustard Oil Seed Cake (MOC) and Neem Oil Seed Cake (NOC) @200g/acre, @ 26.67 t/ha, @2.40 t/ha and 1.71 t/ha Respectively. The data of the experimental year 2016–2017 on crop growth and yield attributes revealed that combination of Azotobacter +MOC gave the highest yield followed by NOC, and FYM+NOC. Combined application of MOC and other oil seed cake (OSC) showed significant increase in growth and yield of wheat, while integration of Azotobacter & MOC with other organic matter improved its effectiveness. Soil bulk density was affected significantly by the application of the treatments. Contrastingly, FYM and MOC alone or gave lower N contents in soil, as compared to the integration of the bio-fertilizer and the organic manures. The results revealed that highest N content in wheat grain and straw were found with Azotobacter and MOC and their integration with other organic amendments.

Keywords: Farm yard manure (FYM), mustard oil seed cake (MOC), neem oil seed cake (NOC) & Azotobacter

1. Introduction

In the world, (*Triticum aestivum* L.) bread wheat, holds a leading position among the food cereals. It contains carbohydrate (70 – 72%) with considerable amount of Protein (10–13%), Fiber (11%), Fat (3%), (Kumar *et al.*, 2011). In India, wheat is major winter (Rabi season) crop throughout the arid and semi-arid zones, and it is generally planted from Mid-October to Mid-November. Wheat is grown in an area of 31.31 million hectares with a total production of 94.9 million tonnes (approximately) in the year 2017 at an average yield of 3,138 kg ha^{-1} in India. On the basis of cultivated land, it has got supreme importance in agriculture. Currently, wheat–fallow is the most common practice in arid and rain-fed areas of the country. It is grown in the Indo-Gangetic plains with the use of high concentrate chemical fertilizers in the last several years causing wide spread of nutrients deficiency in the soil. The decreasing nutrient supplying capacity and lack of several nutrients in the wheat cultivation areas has been observed to be one of the major reasons for the lowering of average yield of the crop in numerous areas in the northern part of India. The technique of soil fertility management is one of the critical components of any cropping system designed to enhance and sustain productivity. Therefore, the technology adaptation for correct dose of fertilizer that can assure economic optimum crop yield as well as sustain soil nutrient reserve, yet not environmentally degrading in the long run is the need of time. The first and most immediate attention should be given to nutrient management system to maintain and increase the productivity of wheat and also to reduce the cost of production by replacing and reducing the use of costly chemical fertilizers and instead increasing the use of ancient method of cultivation by using organic manures. In traditional agriculture, discriminate use of chemical fertilizers deteriorates soil structure, pollutes ground water, and increases nitrate concentration in crops (FAO, 1990; Zhang *et al.*, 2010). Although, the use of mineral fertilizers cannot be over-looked; however, due to their rising costs, and environmental and health concerns, there is a need to supplement or substitute them with available organic resources (Chaudhry *et al.*, 2009). In this perspective, integrated nutrient management including application of organic amendments and agro wastes is practiced to enhance soil fertility and sustain crop production (Hussain *et al.,* 1995, 1999). It helps in keeping the cereals mono-cropping systems greatly productive as well as sustainable (Rajendra *et al.,* 1998).

The role of the organic farming system is to enhance the clean food production, more adequate to human metabolism. In compliance with the environment preservation issue and full respect for nature. The organic farming system contributes to the added value economic activities development and to the interest for rural areas growing. Application of different organic manure to wheat crop could provide a substitute of fertilizer under field condition. In the past, practice of Farm Yard Manure (FYM) are being ignored due to easy availability of low quality and large quantity of manure being used and low cost of chemical fertilizers. They are ploughed down with the soil at the time of land preparation to provide nitrogen rich soil, improve tilth and enhance organic matter in soil, through decomposition. Cereal grain crops could receive additional amount of N from crop rotations including leguminous perennial crops. However, recently the interest of farm yard manure has emerged in the researchers and farmers due to initiation of high yielding cultivars and escalating fertilizer prices. Incorporating the legume crops, agro wastes into the soil even can considerably increase the soil N (Pushpavalli *et al.,* 1994), and reduce the need for N fertilizer in cereal crops (Tanimu *et al.,* 2007). FYM also maintains soil P_2O_5, enhances organic matter contents and improves the soil physical condition and chemical properties (Hussain *et al.,* 1999).

N resource – poor countries, soils are being degraded due to removal and burning of crop residues (FAO, 1990). Retaining of crop residues could be advantageous over burning and physical removal, for nutrient recycling and reduction of evaporation rate from soil surface (Hooker *et al.,* 1982). Farm residues can be recycled effectively for supplementing the plant nutrient requirements and improving soil characteristics, thus, sustaining productivity, reducing fertilizer use, and restoring soil fertility (Patra *et al.,* 2000). Sequestration of carbon in soil relates to the amount of plant residues incorporated, which conserves organic – C through decomposition processes. Therefore, raising the soil organic – C levels requires balanced fertilizer applications and returning of crop residues over the long run (Rajendra *et al.,* 1998).

Good quality organic wastes can be the substitute of chemical fertilizers (Singh *et al.,* 1997) [1]. Cattle's farm yard manure, MOC and NOC, from Oil manufacturing industries both small scale and large scale, are indigenous organic fertilizer sources for crop production. Type of organic material, their quality and application method are momentous for influencing soil characteristics and nutrient recycling. Improvement of soil physical characteristics, e.g., water holding capacity, aeration and granulation is another benefit of organic amendments. Further, they alter the chemical characteristics of soil in favor of crop production, e.g., enhance plant nutrient supply, neutralize the pH, and counter the hazardous effects of salts, toxic chemicals and metals, decreases the attack of fungus and other insect pest to the seed and the roots of the crop. Optimum use of organic materials also encourages biological activities in the soil (Javaid *et al.,* 1998). High biomass producing crops enhance soil productivity by building up organic matter, through vigorous root system, large residues, improved aeration and water infiltration rates. A vigorous crop can also make full use of available soil moisture (Khan *et. al.,* 2005) [5].

Soil organic matter has both anion and cation exchange sites, which could retain plant-available P and K (Khan *et al* 2005) [5]. Addition of two principal N sources, viz., MOC and NOC could significantly boost the efficiency of native P and K, and incorporation of organic manure cover could conserve them. Yang *et al.,* 2006) reported that because different sources of manure have different decay rates, therefore, the rate of mineralized nitrogen for various manures and the rate of N-uptake of different crops are different. Organic farming is gaining popularity across the globe. In Europe, 4.2 million hectares are cultivated organically (Yang *et al.,* 2006). Cereals stand first on the organic farms. Africa and Asia represent comparatively less acreage under organic cultivation. Timing and amount of irrigation water are imperative for producing wheat crop in arid and semi-arid agro-ecologies. Effect of water stress on wheat yield depends on soil type and organic matter content in the rhizosphere, and the way crop uses the limited water supply. (Yang *et al.,* 2006) obtained the highest wheat yield and water use efficiency by irrigating at 75% moisture depletion level. Yang *et al.,* 2006) reported that consumptive use, water use efficiencies and stress levels of wheat irrigated at 80 and 90% moisture depletion level were comparable. Continuous water stress, early water stress, rain fed and late water stress in winter wheat decreased grain yield by 65.5, 40.6, 30.5 and 24%, respectively compared with fully irrigated crops. Positive impact of organic matter on increasing the available water capacity of soil could mitigate the negative effect of short-term drought on young plants until the development of their deeper root system (Yang *et al.,* 2006).

For future, there is a need not just to maintain crop production at the present level but also to raise it significantly for feeding the growing world population. It would mainly depend on enhanced supply of plant nutrients and irrigation water (Yang *et al.,* 2006). There is an obvious realization among the scientists that green revolution through synthetic agricultural inputs has already gone to its peak, and now rendering diminishing return. In this situation, a natural balance needs to be established for sustaining human life and prosperity. Therefore, the study being reported in this manuscript was envisaged and performed to quantify the usefulness of various organic amendments, viz., farm yard manure, mustard cake and neem cake along with the mixture of Azotobacter for increasing wheat production and improving the soil properties in cropping under arid climate. Further, the impact of different combination of organic manuring on efficient utilization of nutrients from soil and applied manure in wheat was studied during this research.

2. Material and methods
2.1 Plant materials
Seed of wheat *var.* HD 3086 – (Pusa Gautami) is a recommended commercially cultivation in irrigated timely sown conditions of North Western Plains Zone comprising the areas of Punjab, Haryana, Delhi, Rajasthan, Western UP, Parts of Jammu & Kashmir, parts of Himachal Pradesh and Uttarakhand under varied cropping systems. This variety matures on an average 143 days. Pusa Gautami has given higher yield ranging from 0.52 to 4.19 % against the checks and qualifying variety. The proposed variety HD 3086 showed a very high degree of resistance against stripe rust and leaf rust with slow rusting type, loose smut and Flag smut as compared to all the checks and qualifying varieties. Pre-

sowing soil sample collection was done representative sample of the soil from experimental field at depth of 0-15 cm were collected from four places randomly at the start of the experiment and a composite sample was made to determine the initial physio-chemical properties of the soil. The composite sample was subjected to mechanical and chemical analysis. The mechanical analysis of soil was done by using International Pipette method (Piper 1966). The physical properties of the soil are presented in Table 1. The soil of experimental field was categorized as loamy sand. The average bulk density of 0-150 cm soil profile was 1.33 g cm^{-3}.

2.2 Chemical analysis
The composite soil sample of 0-15 cm depth was analyzed for pH, electrical conductivity (EC), organic carbon (OC) and available nutrients (nitrogen, phosphorous and potassium) to know their status before sowing of the crop. The soil samples were air dried, ground and sieved through 2 mm sieve. The various chemical properties of soil.

The experimental field tested low in organic carbon and available nitrogen, medium in available potassium and high in available phosphorus. The soil pH and electrical conductivity values were within the normal range.

T_1	Azotobacter
T_2	Azotobacter + FYM
T_3	Azotobacter + NOC
T_4	Azotobacter + MOC
T_5	Neem Oil Seed cake
T_6	Mustard Oil Seed cake
T_7	NOC + FYM
T_8	MOC + FYM
T_9	Farm Yard Manure
T_{10}	Control

Gross plot size- 4m x 1.5m = 6m^2
Net plot size- 3.8m x 1.5m = 5.7m^2
Agronomic Practices- The agronomic practices followed for raising wheat crops are given below:

2.3 Pre-Sowing Irrigation
No irrigation was applied, as adequate soil moisture was present in the field of the previous crops in the soil profile at the time of planting.

2.4 Farm Yard Manure Application
Farmyard manure was applied in calculated amount to supply 125 kg N ha^{-1} before sowing and after germination between the rows and thoroughly mixed in the soil.

2.5 Field Preparation
Usually wheat is taken as second crop after *kharif* as irrigated crop. The field is cross cultivated by tractor after the harvest of *kharif* crop. 2 – 3 harrowing are given for crushing the clods and the stables of previous crop, weeds are picked to make the field clean. One pre-soaking irrigation is given to the field 4 – 5 days prior to sowing. After wapsa condition harrowing and planking's are given to prepare final seed bed for sowing. Saras are made with the help of sarayantra (Ridger) or bund former and irrigation channels are opened by running ridger between two rows of saras after sowing of wheat. The field was ploughed twice with spade and twice with leveler followed by planking to prepare a fine seedbed on 5th December, 2016.

2.6 Seed inoculation
The quantity of seed required for each plot was weighed on the basis of recommended seed rate of 125kg/ha and was kept in different jute bags. Seed were treated with Azotobacter by dissolving the content of packet in a proportion of 1 liter of water plus 100g of Gur/Sugar for the seeds of 1 acre, seeds are soaked for 1 to 2 hours to have even coating on seeds and treated seeds were then placed in a cool and dry place for shade drying. till sowing.

2.7 Seed rate and sowing
The wheat seeds variety HD 3086 were sown in experimental plots on 5th December 2016 following in line sowing method. Row to row and plant to plant distance was 22.5cm and 5cm respectively. In each hill, 2-3 seeds were sown and sowing depth was maintained at about 3-5cm from the soil surface. A seed rate of 125 kg ha^{-1}. After sowing the seeds were covered with a thin layer of loose soil with the help of plank after sowing of the seeds.

2.8 Weeding and thinning
Weeding and thinning were done on 15 – 20 DAS when the plants attained the height of about 5 to 9 cm. Plant to plant distance was maintained. Second weeding and thinning were done on 30 - 40 DAS when the plant attained about 15 – 20cm height.

2.9 Irrigation
One post sowing irrigation was applied on 26th December 2016 at CRI stage followed by the time of ear initiation stage in wheat. The crop received 105.4 mm of rainfall during the complete growth season.

2.10 Weed control
Weeds were kept under check with two hand hoeing at 30 and 70 days after sowing (DAS).

2.11 Harvesting and threshing
The harvesting of wheat was done manually with the help of sickle by the labours on 20th April, 2017 from the net plot area. The harvested crop was tied in well labelled bundles and kept for sun drying for three days. Then the threshing was carried out.

Operations	Date
Pre-sowing irrigations	Not given due to presence of adequate moisture
FYM application	At land preparation
Preparatory tillage, field preparation and Layout of the experiment	At land preparation
Sowing of wheat seeds	5 – 12 – 2016
Thinning	15 DAS
First periodic observation	20 DAS
1st Irrigation	21 DAS (CRI)
Application of OSC	25 DAS
Second observation	40 DAS
2nd Irrigation	Tillering stage
Third periodic observation	60 DAS
3rd Irrigation	Late Jointing Stage
Fourth periodic observation	80 DAS
4th Irrigation	(Flowering Stage)
Fifth periodic observation (100 DAS)	100 DAS
Harvesting	136 DAS
***DAS** – Days After Sowing	

2.12 Observations recorded

Data were collection started after 20 DAS and recorded at regular interval on plant growth attributes at various stages of growth. For Plant Height, Five plants per plot were selected randomly to measure the height from ground level to the tip of longest leaf at 20 days after sowing (DAS), up to the base of top most fully opened leaf at 60 DAS, up to the base of flag leaf at 90 DAS and up to the base of the ear at harvest. For Plant growth attributes, three plants from each unit plot were uprooted carefully keeping maximum roots in them and encased in polythene bags to avoid transpiration loss and then brought to the laboratory for recording the data on different parameters. Sampling was done at 20 DAS till maturity and the following attributes were studied. For Morphological parameters, Plant height (measured in cm from the base of a plant to the apex of topmost leaf), Number of tillers/plants, Number of leaves/plant, Number of ear/tiller, Number of fertile tillers/plant. Measurement of Crop Attributes Following measurements related to growth and grain yield of wheat were made in all the experiments almost unanimously. Agronomic-Seed germination count (1 m^2), Number of total tillers (1 m^2), Plant height (cm), Number of spikelets (per spike), Number of grains (per spike), 1000-grain weight (g), Grain yield (kg/ha), Harvest Index.

2.13 Dry matter accumulation

Above ground plant samples from 50 cm row length were taken periodically at 20, 40, 60, 80, 100, 120 and 136 DAS and at harvest. The samples were first sun dried and thereafter, they were kept in an oven at a temperature of 72ºC to achieve constant weight. The dry weight thus obtained was recorded and expressed as quintal ha^{-1}. Total number of tillers per metre row length, Total number of tillers per metre row length was recorded at 20, 40, 60, 80, 100, 120 and 136 DAS and at harvest from two sites in each plot, Length of spike, Three spikes were selected at random from each plot and their length excluding awns was measured and then averaged values were calculated. The average length was expressed in cm., Number of grains $spike^{-1}$Randomly selected three spikes were taken from each plot and threshed manually. The number of grains were counted and averaged for number of grains spike-1, 1000-grain weight, One thousand grains from produce of each plot were taken and their weight was recorded. The thousand-grain weight was expressed in grams, Grain and straw yield, the total produce was weighed in bundles after harvesting and threshed thereafter. The weight of grains was recorded. The straw weight was obtained after deducting the weight of grains from total bundle weight. Grain and straw yield were computed and expressed as quintal ha^{-1}.

2.14 Harvest index (HI)

HI was calculated by dividing economic (grain) yield by the total biological (grain + straw) yield and expressed as percentage.

$$\text{HI (\%)} = \frac{\text{Economic yield}}{\text{Biological yield (Grain+Straw)}} x\ 100$$

2.15 Days to maturity

Days to maturity were recorded with visual observation. The number of days taken from sowing to maturity was recorded when all the plants in net plot were ready to harvest. Complete loss of green colour from glumes and peduncle was used as criterion for recording days to maturity.

2.16 Cost Benefit Ratio

Cost benefit ratio was calculated by using the following equation:

$$\text{Cost Benefit Ratio} = \frac{\text{Value of Increased Yield}}{\text{Cost of Additional Expenditure}}$$

2.17 Soil Analysis

Soil organic carbon: 1g soil in 10ml of 0.1667 M $K_2Cr_2O_7$ solution, 20ml concentrated H_2SO_4, 200ml water for dilution, 10ml H_3PO_4, 10ml of NaF solution, diphenylamine as an indicator, 0.5 M $FeSO_4$ solution as a titrant. During dilution, different soil sample shows a variation in colour i.e. some are orange and some are dark green, but with the same end point of light greenish colour after titration.

Table 3.27.11: Soil Characteristics of the field before sowing and after harvesting wheat in 2016–17

Attributes	Pre-sowing of wheat	Post-harvest of Wheat
Texture	Loamy Sand	
Volumetric water content of soil	0.23	24
EC (ds/m)	1.53	1.34
Organic Matter %	0.23	0.27
Soil Organic Carbon	0.35	0.35

2.18 Statistical Analysis

Crop data on growth, yield parameters and nutrients content, and soil nutrient status of all experiments were statistically analyzed separately for each year through one-way analysis of variance – ANOVA (Quarrie *et al*., 2007) using MSTAT-C statistical computer program. Treatment means for various crop and soil attributes were compared by Duncan's multiple range test – DMRT. In case the difference between two years' data of any parameter was non-significant, then both years' data were pooled together and analyzed statistically by two-way ANOVA technique and pooled means were compared through WASP (Quarrie *et al*., 2007).

3 Result and Discussion

The study entitled ― "Effect of Oilseed Cake and Bio-Fertilizer on Productivity of Wheat (*Triticum aestivum* L.)" was conducted at Student's Research Farm, Department of Agronomy, Amity Institute of Organic Agricultural, Amity University, Noida, during *Rabi* 2016–17. This chapter comprises the presentation and discussion of the results from the experiment conducted to determine the effects of different OSC on growth and productivity of wheat. The data of the results have been presented in tabular and graphical forms for the convenient of presentations. The results of each parameter have been discussed have been given under the following headings and sub-headings.

3.1 Effect of Oilseed Cake and Bio-Fertilizer on Productivity of Wheat (*Triticum aestivum* L.)

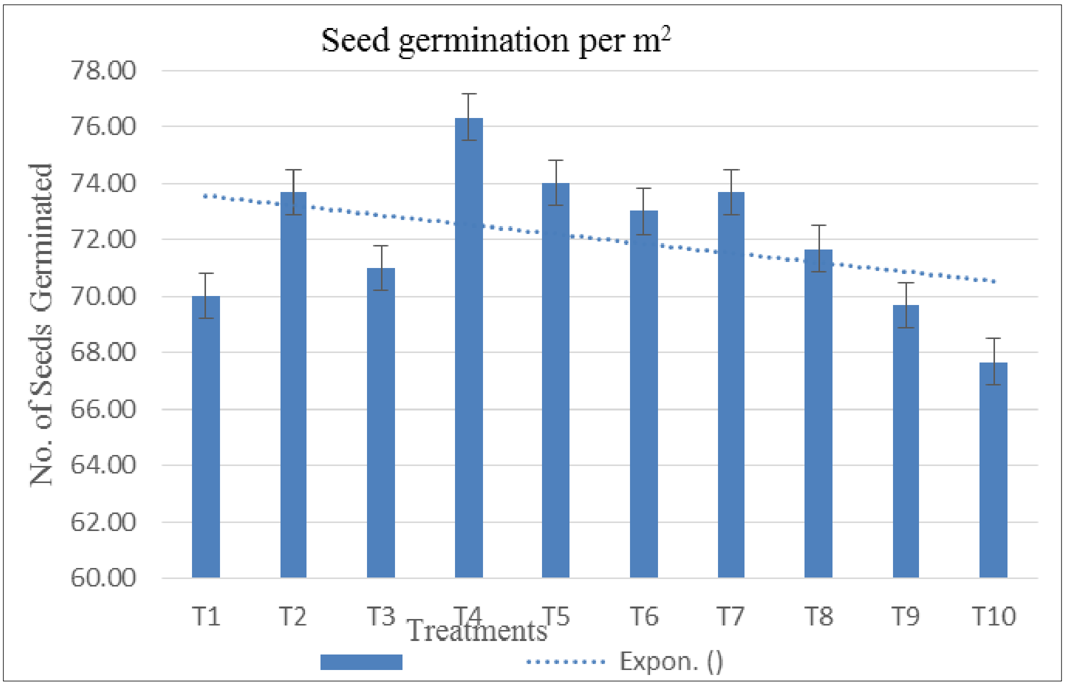
This experiment was started to study and compare the efficiency of various organic manures used as alone and in combination, and to find out the best treatment for the growth and yield of wheat. Spinach crop was grown in the preceding season of wheat in the entire experimental field uniformly. The crop was harvested soon the field was rotavated and mixed well, and then the field was irrigated for enhanced decomposition. The organic matter sources/treatments used in the study were: farmyard manure (FYM), Mustard cake (MOC), Neem cake (NOC), and Azotobacter (Azotobacter). The amount of each organic amendment used singly was calculated and applied accordingly referring to the amount of nitrogen needed by the wheat crop in the specified cropping size plots. The amount of each organic amendment used singly was Azotobacter, Farm Yard Manure (FYM) @ 26.67 t/ha, Mustard cake (MOC) @2.40 t/ha and Neem cake (NOC) @ 1.71 t/ha. The experiment was conducted on wheat as test crop for growing seasons. Initial supporting data on crop growth parameters recorded at 20, 40, 60, 80, 100, 120 and 136 days after sowing (DAS) are presented in the Appendices (II). Data on various attributes of crop growth at 136 DAS and yield, and post-harvest status of soil are discussed in the following paragraphs:

3.2 Seed Germination

Healthy seedlings of germinated wheat seeds were counted at 10 DAS from one square meter area. Results reflected that application of all types of organic materials (Azotobacter, FYM, MOC and NOC) and their combinations improved the germination of wheat seeds significantly over control (Table 4.2). There was no significant difference between data, on the first reading date so they were pooled together and analysed statistically. Pooled average data infers that single as well as combined use treatments of organic manures had no significant difference among themselves. Number of germinated seeds was significantly higher under combined Azotobacter+MOC application followed by NOC alone and NOC+FYM amendments. Among the organic amendments combinations, the lowest germination count was recorded with FYM treatment, which still gave higher germination count than in control. Single application of both Azotobacter and FYM gave significantly lower seed germination as compared to their combination in half of their amount. Conversely, seed germination was lowered by combined application of some organic amendments (Azotobacter+FYM, Azotobacter, FYM) as compared to that with their sole application. There was no obvious reason for such contrasting results.

Table 4.2. Effect of sole manure and application of combination of different organic manures on seed germination per m^2 at 10 DAS of Wheat

Treatments		Seed Germination 10 DAS
T_1	Azotobacter	70.00
T_2	Azotobacter + FYM	73.67
T_3	Azotobacter + NOC	71.00
T_4	Azotobacter + MOC	76.33
T_5	NOC	74.00
T_6	MOC	73.00
T_7	NOC+FYM	73.67
T_8	MOC+FYM	71.67
T_9	FYM	69.67
T_{10}	Control	67.67
CD (5%)		**NS**



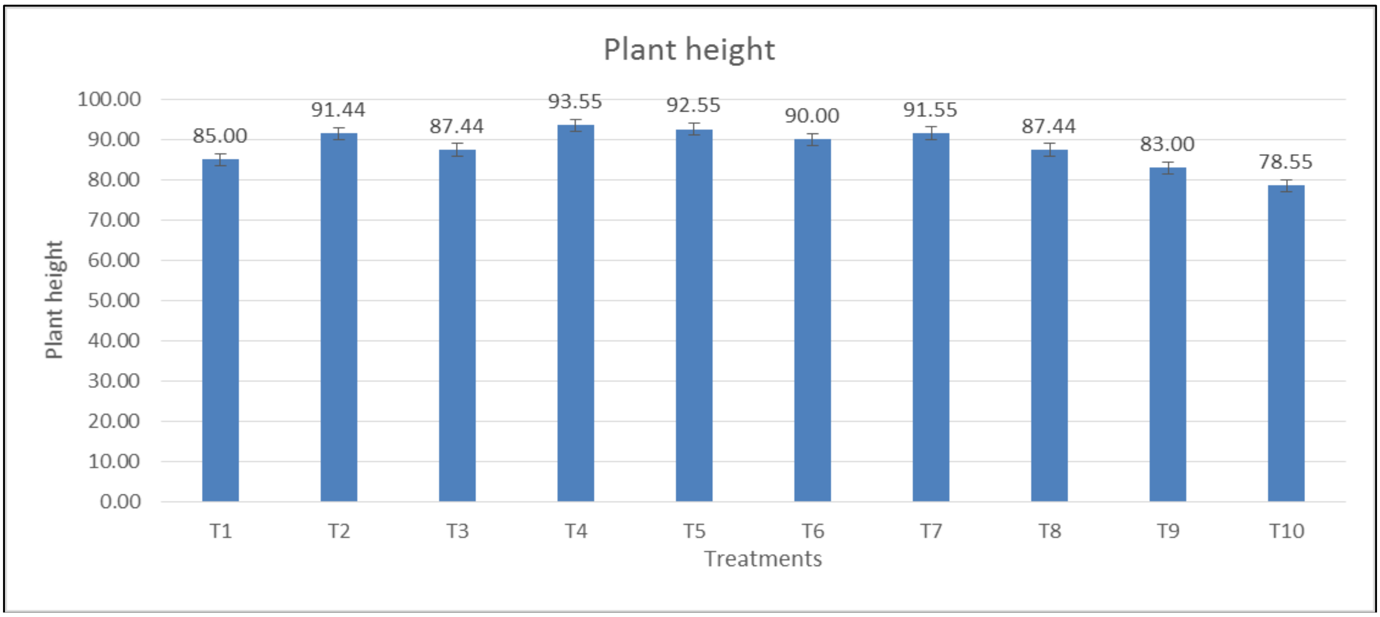
Graph 4.2: Number of seeds germinated 20 DAS per m^2

3.4 Plant height

Plant height is an important index of the plant development. It gives an idea to predict the growth rate and yield of the crop. The perusal of data on periodic plant height indicated a progressive increase in plant height with the advancement in age of the crop. The periodic plant height at 20, 40, 60, 80, 100, 120 and 136 days after sowing (DAS) and at harvest are presented in Graph 1 indicated that application of different organic amendments sole or in combinations gave significant increase over control during the cultivation (Table 4.3). At early stage of growth, there was little variation in the plant height among the different treatments. The maximum plant height (32.9 cm) at 40 DAS was observed in Azotobacter+MOC which was statistically at par with sole OSC and combinations There was statistical difference between the observed data, so they were pooled and analysed statistically together to see the variation occurred in the different treatments. Average data infers that single as well as combined use of organic manures had significant difference among themselves. Organic manure is a good source for N supply to crop plants. Type of organic material and its quality effect the soil characteristics and nutrient source to the crops variably. Because various sources of manure have different decay rates, therefore, the amount of mineralized nutrients from these manures and the rate of nutrient uptake by the crop vary. Addition of nutrients from all the organic sources and their combinations enhanced the plant growth, so the plant height. The highest values of plant height were found with the application of Azotobacter+MOC followed by NOC alone and NOC+FYM, with a significant difference among them. Further, all the organic materials differed significantly with each other, and both FYM and control gave the shortest length of wheat plants. Among the combinations of organic amendments, the shortest plants were observed in control. Height of wheat plants was reduced by combining MOC + FYM with Azotobacter + NOC, and FYM Control as compared to that with their sole application.

Table 4.3: Effect of single manures and application of combination of different organic manures on plant height (cm) at 20, 40, 60, 80,100,120 and 136 DAS of wheat.

Treatments	40 DAS	60 DAS	80 DAS	100 DAS	120 DAS	136 DAS
T_1	31.00	39.00	67.77	83.11	85.00	85.00
T_2	34.55	42.77	76.55	88.00	90.00	91.44
T_3	31.77	42.55	72.00	85.22	87.44	87.44
T_4	38.00	51.00	85.00	93.00	93.55	93.55
T_5	37.11	50.00	81.00	89.11	92.89	92.55
T_6	32.00	42.00	75.00	87.22	90.00	90.00
T_7	32.77	45.00	79.00	89.11	91.44	91.55
T_8	32.00	41.00	70.44	83.22	87.44	87.44
T_9	31.00	38.00	67.00	81.11	83.00	83.00
T_{10}	27.77	36.00	62.00	78.00	78.00	78.55
CD (0.05)	1.514	0.868	0.982	0.271	0.691	0.509



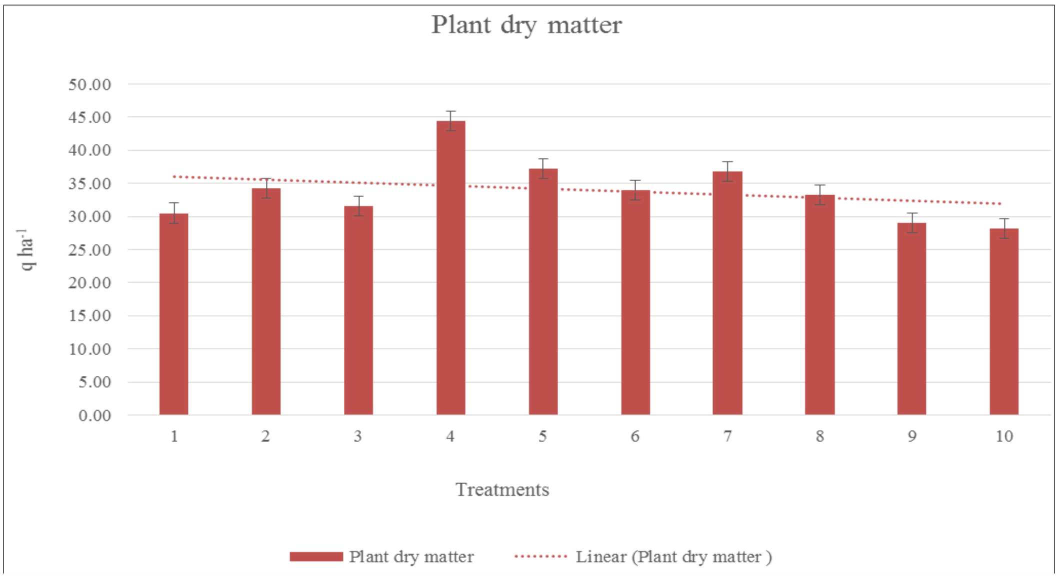
Graph 4.3: Effect of single manures and application of combination of different organic manures on plant height (cm) at 20, 40, 60, 80,100,120 and 136 DAS of wheat

3.5 Dry Matter Accumulation:

Dry matter accumulation is one of the most important parameters and has a marked influence on final yield realization of a crop. Dry matter accumulation is the result of total accumulation of photosynthates formed and total nutrient uptake by the plant up to the stipulated growth period. Dry matter accumulation has significant role in plant proliferation. Data pertaining to dry matter accumulation at 20, 40, 60, 80, 100, 120 DAS and at harvest are presented in (Table 4.4). The dry matter accumulation increased continuously with the age of crop. At 20 DAS, the dry matter accumulation was constant in all treatments with a highest reading value of 2.9 q ha^{-1} followed by minimum value of 2.5 q ha^{-1}. Dry matter variances were observed after the Tillering stage with a maximum dry matter accumulation 5.98 q ha^{-1} followed by 3.5 q ha^{-1} was recorded in Azotobacter+MOC followed by sole NOC and it was statistically at par in ratio with other treatments, but significantly higher than others. Similarly, all the data was collected periodically and it is mentioned in the (Table 4.4)

Table 4.4: Effect of single manures and application of combination of different organic manures on plant dry matter (q ha^{-1}) at 20, 40, 60, 80,100,120 DAS and at harvest of wheat.

Treatments		136 DAS
T_1	Azotobacter	30.50
T_2	Azotobacter + FYM	34.27
T_3	Azotobacter + NOC	31.57
T_4	Azotobacter + MOC	44.43
T_5	NOC	37.17
T_6	MOC	33.97
T_7	NOC+FYM	36.77
T_8	MOC+FYM	33.27
T_9	FYM	29.00
T_{10}	Control	28.20
CD		0.426



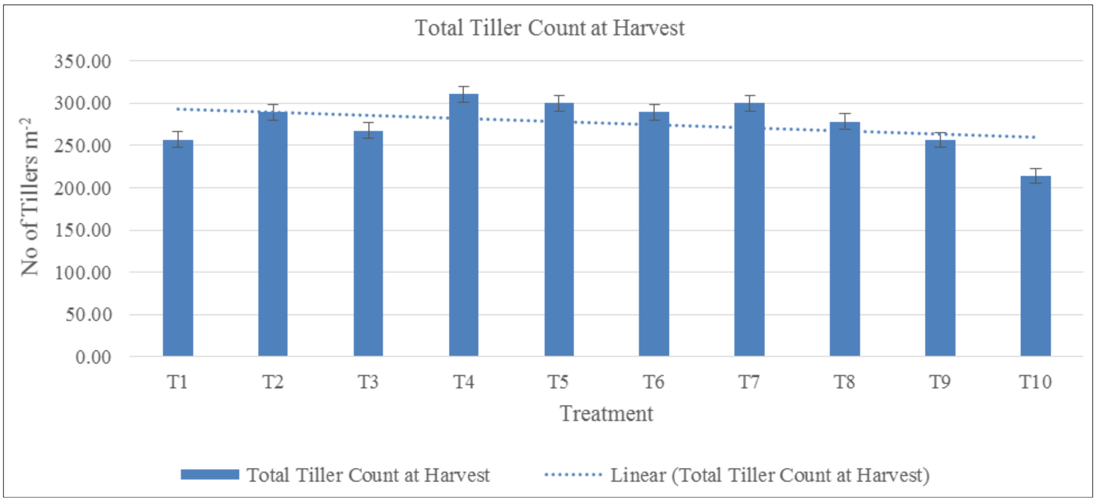
Graph 4.4: Effect of sole manures and application of combination of different organic manures on plant dry weight (q ha^{-1}) at 20, 40, 60, 80,100,120 DAS and at harvest of wheat treatment wise.

3.6 Total Tillers Count

Number of total tillers of wheat was recorded from 1 m^2 area at harvesting stage (136 DAS). Use of different organic amendments singly or in combinations significantly increased the total tillers count of wheat over control during the cultivation years (Table 4.3). There was significant difference between the different treatments of the crop sown in the cultivation, so they were pooled together and analysed statistically. Pooled average data infers that single as well as combined use treatments of organic manures had significant difference among themselves. As most of the cultivated soils in the country developed from calcareous alluvium and loess, so they are low in organic matter as well as in many essential plant nutrients. Therefore, addition of nutrients from any organic source enhanced the plant growth, so the number of tillers. The highest count of total tillers per unit area was with the application of Azotobacter+MOC alone followed by NOC and FYM+NOC, with a significant difference among them. Further, all the organic materials differed significantly with each other except FYM and Control, both of them gave the lowest tillers count of wheat after FYM and Azotobacter. Among the combinations of organic amendments, the lowest tillers count was recorded with Azotobacter+NOC, however, it produced significantly higher number of tillers than in control. Plant nutrients, polysaccharides and other organic compounds released during decomposition of organic matters lead to the increased number of crop leaves and tillers. Number of wheat tillers was reduced by application of MOC+FYM amendments as compared to that with their sole application. However, other combinations gave results in between to their sole use. Azotobacter+MOC was found superior whether used as in combination and reduced when used with other organic materials. It was due to its higher manure value or nutrient composition than that of others.

Table 4.5 Effect of sole manure and application of combination of different organic manures on total tillers count m^2 at (136 DAS) day of wheat harvesting.

Treatments	Total Tiller Count at Harvest
T_1	257.00
T_2	289.00
T_3	267.67
T_4	310.33
T_5	299.67
T_6	289.00
T_7	299.67
T_8	278.33
T_9	256.67
T_{10}	214.00
CD	**0.838**

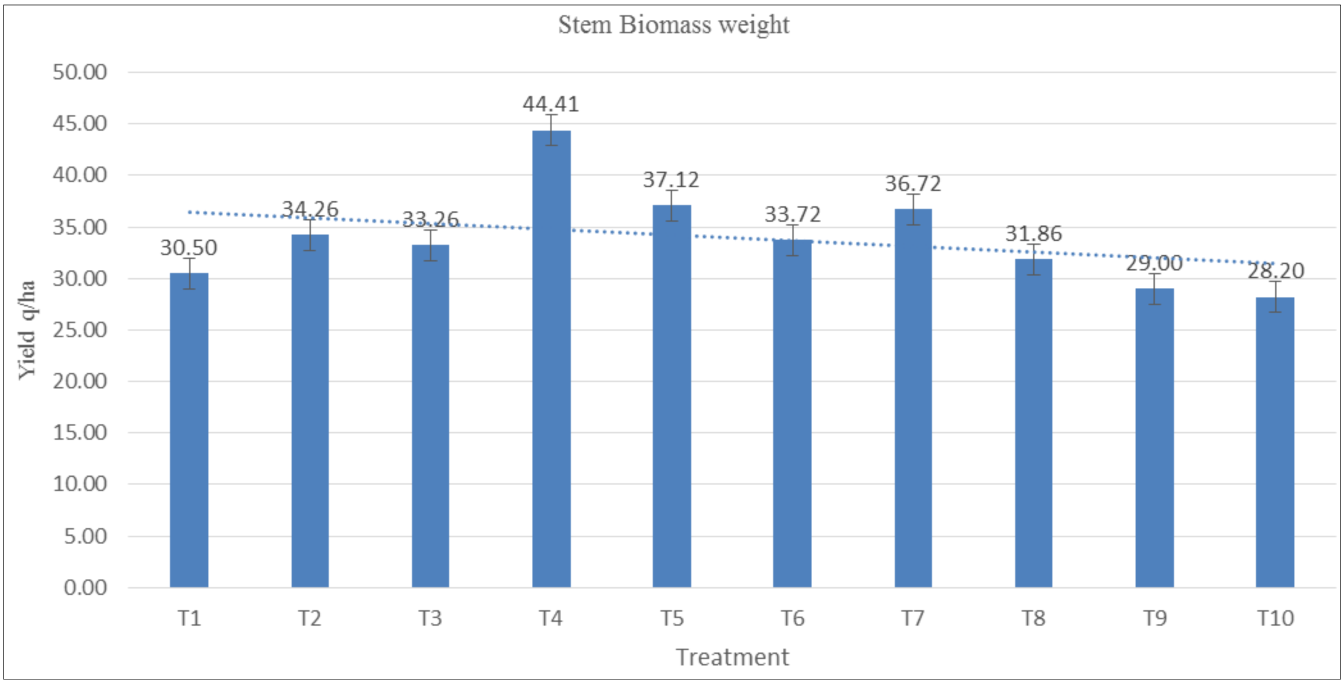


Graph 4.5: Effect of sole manure and application of combination of different organic manures on total tillers count m^{-2} at 136 DAS of wheat

3.7 Stem Biomass Weight
Biomass weight of wheat stems (fresh as well as dry) recorded at the time of crop harvest was significantly higher with the use of various organic manures alone or in combinations as compared to that in control during both the years (Table: 4.6). Response of fresh and dry biomass weight of stems was similar to various treatments. There was significant difference between the different treatments data of stem biomass weight. The highest values of stem biomass weight were recorded with the application of Azotobacter+MOC alone followed by NOC alone and NOC+FYM, with a significant difference among them and with rest of the treatments. Further, all the organic materials differed significantly with each other, and both FYM and control gave the lowest stem biomass weight of wheat plants. Among the organic manures combinations treatments, the lowest shoot biomass weight was observed in MOC+FYM and Azotobacter+NOC, however, they were significantly superior to control. Increase in crop biomass weight with manure treatments might be due to efficient use and continued supply of the required plant nutrients as well as more water.

Table 4.6: Effect of single manures and application of combination of different organic manures on stem biomass weight (g) at (136 DAS) harvest of wheat crop.

Treatments	Stem Biomass Weight (g)
T_1	30.500
T_2	34.257
T_3	33.257
T_4	44.410
T_5	37.123
T_6	33.723
T_7	36.723
T_8	31.857
T_9	29.000
T_{10}	28.200
CD	**0.590**

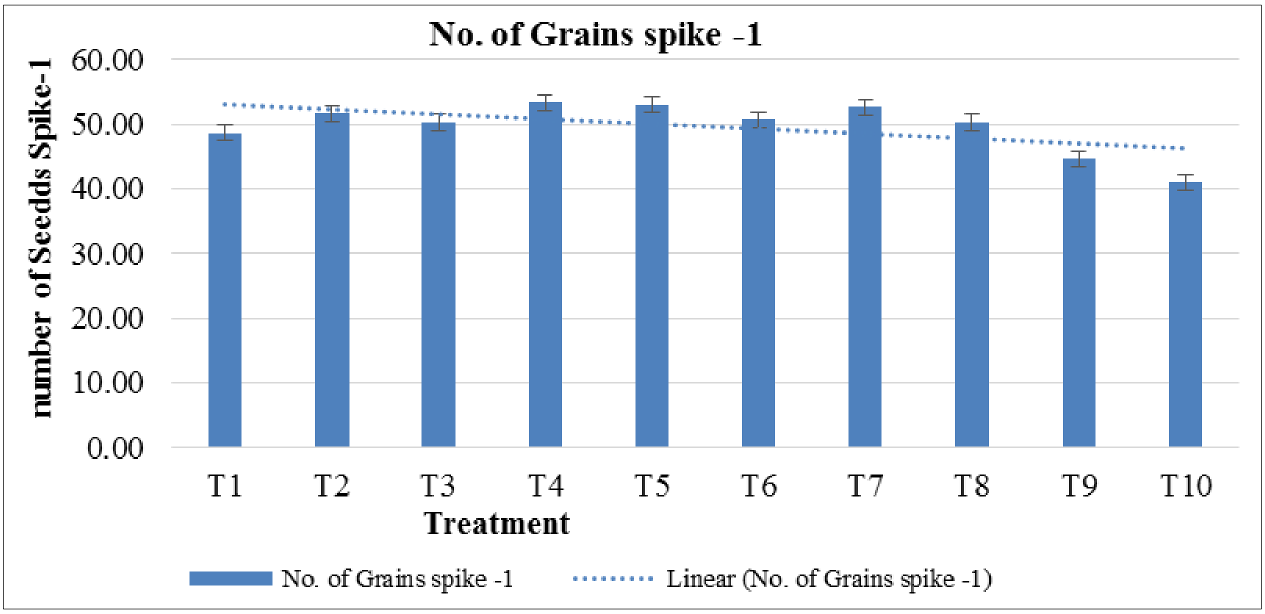


Graph 4.6: Effect of single manures and application of combination of different organic manures on stem biomass weight (g) at (136 DAS) harvest of wheat crop.

3.8 Grain Count:
Number of grains per spike of wheat was counted after crop harvest; data showed that single application of various organic amendments or in combinations increased the grains count significantly over control in all the different applications of the treatments (Table: 4.6). There was significant difference between the data of all the different treatments hence, the data was pooled and indicates that sole as well as combined use treatments of organic manures had significant difference among themselves. The highest number of grains per spike was recorded with the application of Azotobacter+MOC followed by the application of NOC alone, and NOC+FYM. Within the single use of organic materials, both FYM and Control gave significantly lower grain count; however, greater than with MOC+FYM, and Azotobacter+NOC. Among the combinations o=f organic amendments, the least grains count was noted in control.

Table: 4.7: Effect of sole manure and application of combination of different organic manures on grains count at harvest of wheat spike^{-1}

Treatments	No. of Grains spike $^{-1}$
T_1	48.67
T_2	51.67
T_3	50.33
T_4	53.33
T_5	53.00
T_6	50.67
T_7	52.67
T_8	50.33
T_9	44.67
T_{10}	41.00
CD	0.480



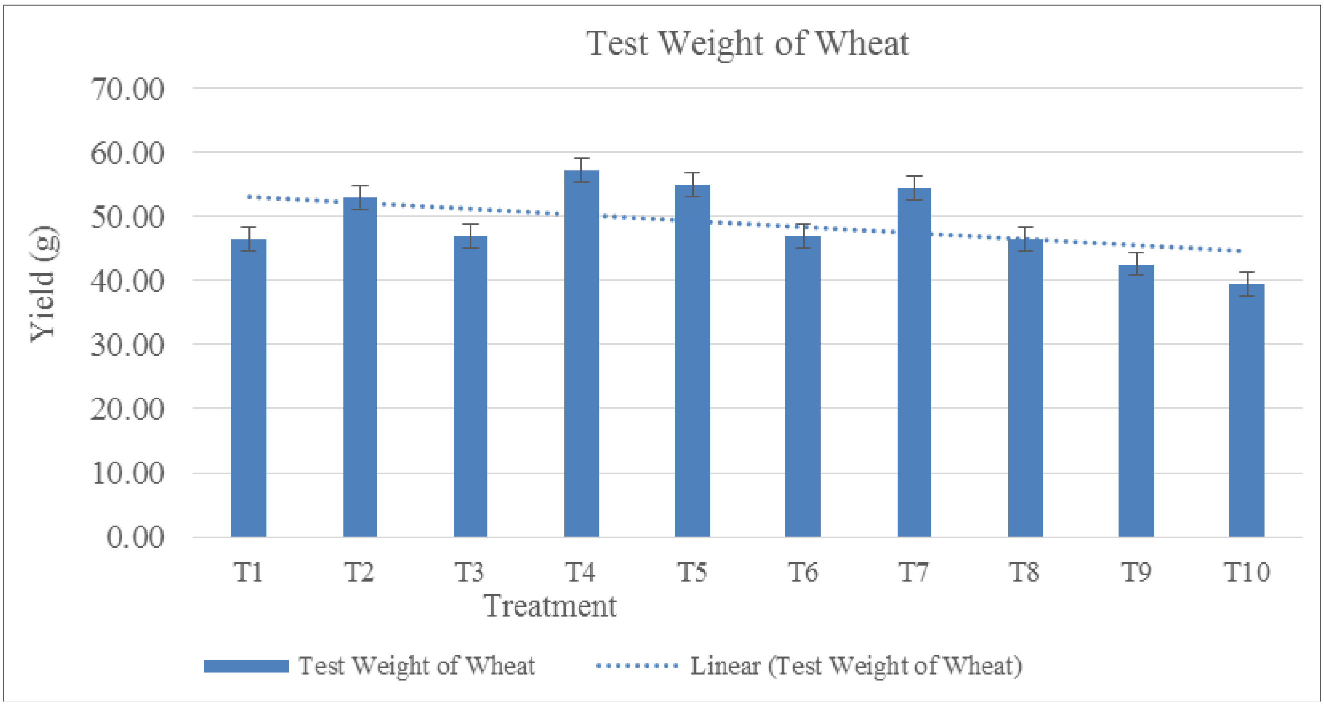
Graph: 4.7: Effect of sole manure and application of combination of different organic manures on grains count at harvest of wheat spike^{-1}

3.9 Test weight of Grain

Weight of 1000-grains of wheat was influenced significantly and differently by various treatments applied sole or in combination as compared to that in control (Table 4.7). Difference between the data of 1000- grain weight was non-significant, so their data were pooled together and analysed statistically. The highest 1000-grain weight was recorded with the sole application of Azotobacter+MOC followed by NOC and NOC+FYM, all having significant difference among them. The organic manures differed significantly with each other, FYM and control gave the lowest 1000-grain weight of wheat. Among the combinations of organic manures, the lowest weight of 1000-grain was observed in control and all combination treatments were superior to control in statistical terms. Weight of wheat grains was increased by combining Azotobacter with MOC and NOC as compared to that with their sole application and others.

Table 4.8: Effect of single manures and application of combination of different organic manures on 1000 seed grain count weight of each replicate.

Treatments	Test Weight of Wheat
T_1	46.44
T_2	53.00
T_3	47.00
T_4	57.22
T_5	55.00
T_6	47.00
T_7	54.44
T_8	46.44
T_9	42.56
T_{10}	39.44
CD	0.643



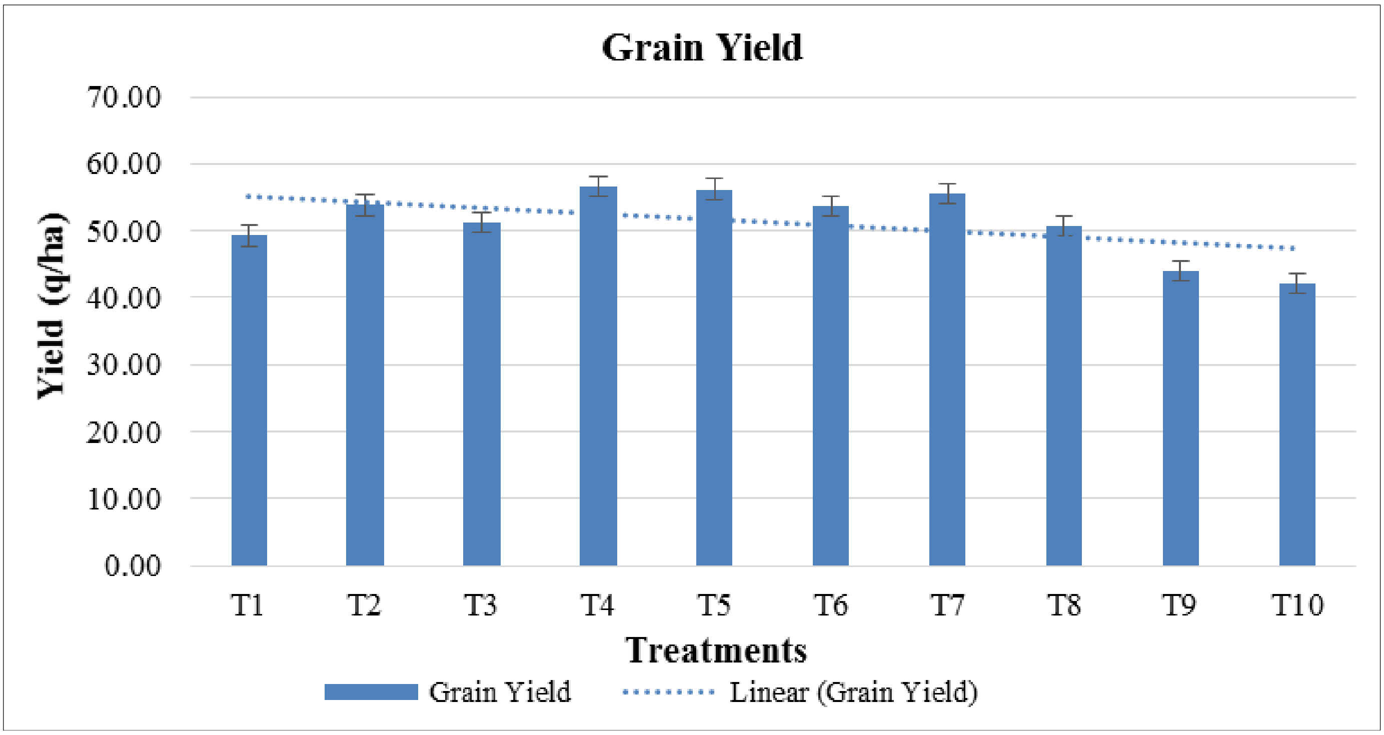
Graph 4.8: Effect of single manures and application of combination of different organic manures on 1000 seed grain count weight of each replicate

3.10 Grain yield

Wheat grain yield was significantly increased under various organic manures used alone or in combinations as compared with control (Table 4.8). Significant difference was observed between the grain yield data of different treatments, with greater yield in MOC and NOC. Data indicates that sole as well as combined use treatments of organic manures had significant difference among themselves. The highest grain yield was obtained with the application of Azotobacter+MOC followed by NOC alone, and NOC+FYM, with a significant difference among themselves. All the organic materials differed significantly with each other, and FYM produced the low grain yield as compared to other manures if used singly and the control plot treatment yielded least. Among the combinations of organic manures Azotobacter+NOC gave the least yield.

Table 4.9: Effect of single manures and application of combination of different organic manures on grain yield of each replicates in quintals ha^{-1}.

Treatments	Grain Yield
T_1	49.30
T_2	53.89
T_3	51.27
T_4	56.60
T_5	56.20
T_6	53.68
T_7	55.55
T_8	50.71
T_9	43.99
T_{10}	42.13
CD	**0.921**



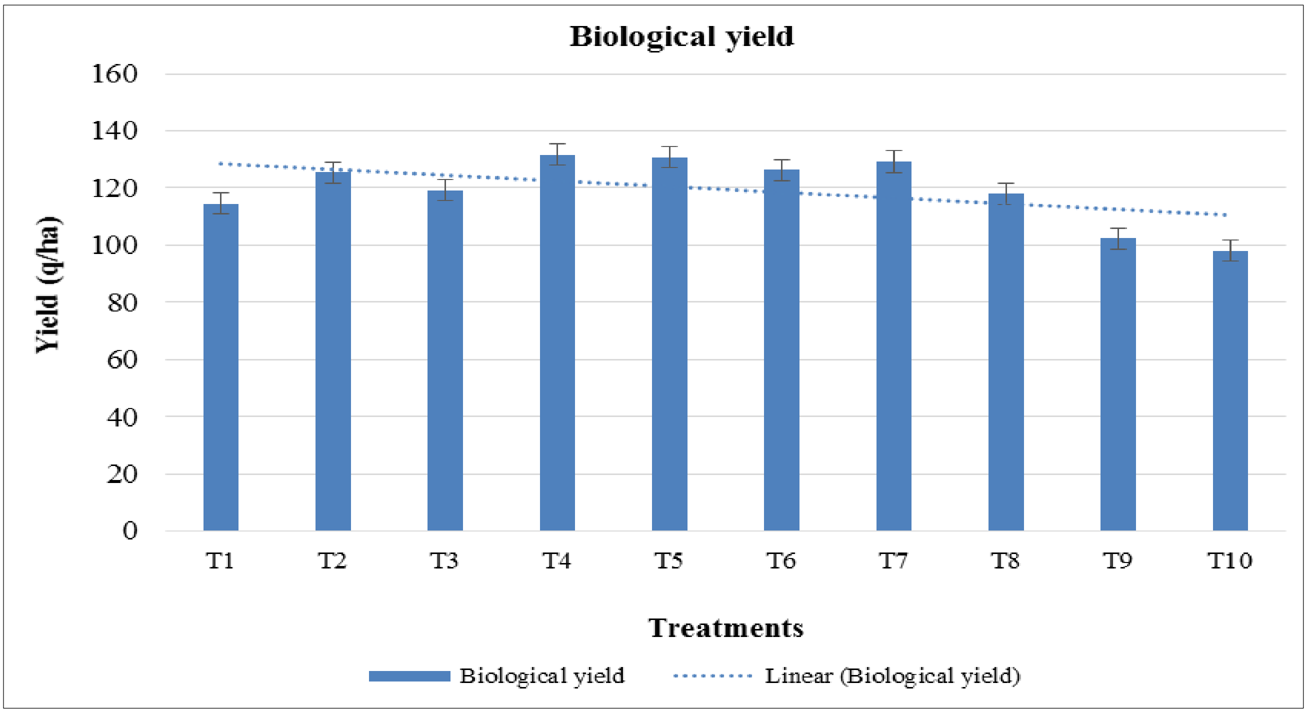
Graph 4.9: Effect of single manures and application of combination of different organic manures on grain yield of each replicates in quintals ha^{-1}.

3.11 Biological yield

Biological yield of wheat recorded after crop harvesting showed a significant increase under the treatments of various organic manures used singly or in combinations as compared with control (Table 4.9). There was significant difference between data, with higher values during the experimental trial. The recorded data reflected that sole as well as combined use treatments of organic manures had significant difference among themselves. The highest biological yield was obtained with the application of Azotobacter+MOC followed by NOC alone and NOC+FYM, with a significant difference among them. All the organic materials differed significantly with each other, FYM alone produced the low biological yield as compared to other but greater than control. Among the combinations of organic amendments, the lowest biological yield was obtained with Azotobacter+NOC, although significantly higher than in control.

Table 4.10: Effect of single manures and application of combination of different organic manures on biological yield of each replicate's quintal ha^{-1}.

Treatments	Biological yield
T_1	114.66
T_2	125.33
T_3	119.22
T_4	131.64
T_5	130.69
T_6	126.39
T_7	129.19
T_8	117.92
T_9	102.3
T_{10}	97.98
CD	**0.925**



Graph 4.10: Effect of single manures and application of combination of different organic manures on biological yield of each replicate's quintal ha^{-1}.

4 Summary

Wheat, the world's most important crop, and is cultivated in an area of 31.38 million hectares with a production of 94.91 million tonnes in India during 2016-17. In India Uttar Pradesh is the highest wheat producing state followed by Punjab and Haryana, and Punjab is the leading state in productivity of wheat in India. Rice–Wheat is the predominant cropping system in Punjab. Wheat is cultivated in *Rabi* season throughout the country and is cultivated mainly in semi-arid and warm temperate regions of the world. India is the second largest producers as well as the consumer of wheat. With a maximum production of the sole application of Azotobacter + MOC followed by NOC and NOC + FYM, all having significant difference among them. Oil seed cakes Khan *et. al.*, (2005) [5] application reported that spike length, number of grains $spike^{-1}$ and grain yield of wheat was significantly higher. Keeping this in view, the present study entitled "Effect Of Oilseed Cake And Bio-Fertilizer On Productivity Of Wheat (*Triticum aestivum* L.)" was undertaken to investigate the objectives of comparing the productivity of organically manured wheat and to find out the suitable organic manure for higher production. The field experiment was conducted at Student's Research Farm, Department of Organic Agriculture, Amity University, Gautam Buddha Nagar, during *Rabi* season 2016-17. The soil of the experimental site was loamy sand in texture with normal soil pH (8.4) and electrical conductivity (0.34 dS/m), low in organic carbon (0.35%), available nitrogen (0.025%) and medium in available potassium (147.5 kg ha^{-1}) and high in available phosphorus (52.3 kg ha^{-1}). Nine treatments of wheat organic manure combinations were evaluated in randomized complete block design with three replications. The results obtained The Number of Seed Germinated 20 DAS m^2 wheat seeds with different treatments of manures was found to be non-significant. Plant Height was found to be significant with each other in the treatments in every replicate and readings was recorded at the regular interval manually, the Comparison of Treatment Means with Critical Difference (0.05) are T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_9. Similar results were observed in the mustard crop (Khan *et al* 2005) [5]. Dry matter Accumulation from the Table 4.4 it is observed that dry matter accumulated in the plants at 20 DAS was found to be non-significant. Later with the increase in DAS the plant dry matter was noted to be significantly different with each other. The observed record show that, T_5 and T_4 was recorded to be maximum but T_5 at 40 DAS was at par significantly greater than T_4 followed by T_7 and T_2 with same critical difference but T_7 at par greater than T_2 followed by T_6. At 60 DAS and later it was observed that T_4 was found to be maximum followed by T_5 and least plant height was observed in T_{10} followed by T_9. Total Tiller Count m^2 From the Table 4.5 it is found that T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_1 (Khan *et. al.*, (2005) [5]. Stem Biomass Weight from the Table 4.6 it is found that T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_9. Grain Count from the Table 4.7 it is found that T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_9 (Khan *et al* (2005) [5].

Test weight of Grain from the Table 4.8 it is found that T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_9. Grain Yield from the Table 4.9 it is found that T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_9 (Khan *et al* (2005) [5]. Biological Yield from the Table 4.10 it is found that T_4 was found to be maximum and T_5 was also found to be maximum but T_4 was at par greater then T_5, followed by the different treatments who were significantly different with each other. The least plant height was observed in the T_{10} followed by T_9.

5 Conclusion

The effects of different oil seed cake and bio fertilizer manures amendment on the productivity of wheat was observed experimentally and the among all the treatments, combination of Mustard oil seed cake plus Azotobacter gave the best response in every aspect of wheat growth, development, maturity, pod size, weight, height and resulted highest in terms of both quality and quantity in response to wheat. Neem oil seed cake manure also gave good result but mustard in combination with azotobacter was at par significantly better than all the treatments. Suitable organic nutrient management practice in the above entitled research trial for proper growth and yield of Wheat is fund to be Mustard Oil Seed Cake with combination of Azotobacter followed by Neem Oil Seed Cake with a highest productivity and growth. The least recorded treatment in the research trial was control followed by Farm Yard Manure. In comparison to all the combinations of treatments the sequence of best recorded treatment effect in decreasing order is enlisted as follows: T_4 Azotobacter + Mustard Oil Seed Cake, T_5 Neem Oil Seed Cake, T_7 Neem Oil Seed Cake + Farm Yard Manure, T_2 Azotobacter + Farm Yard Manure, T_6 Mustard Oil Seed Cake, T_8 Mustard Oil Seed Cake + Farm Yard Manure, T_3 Azotobacter + Neem Oil Seed Cake, T_1 Azotobacter, T_9 Farm Yard Manure, T_{10} Control.

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7. References

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