COMPARATIVE STUDY OF CONVENTIONAL AND BIODYNAMIC COMPOST ON PERFORMANCE OF ORGANIC CHICKPEA

THESIS

Submitted to
Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola
in partial fulfilment of the requirements
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AGRICULTURE
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By

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Enrolment Number - LL/1012 **2019**

DECLARATION OF STUDENT

I hereby declare that the experimental work and its interpretation in the thesis entitled **"COMPARATIVE STUDY OF CONVENTIONAL AND BIODYNAMIC COMPOST ON PERFORMANCE OF ORGANIC CHICKPEA"** or part thereof has neither been submitted for any other degree or diploma of any University, nor the data have been derived from any thesis / publication of any University or scientific organization. The source of materials used and all assistance received during the course of investigation have been duly acknowledged.

Place : Akola **(BAYSKAR AKSHAY SATISHRAO)**

Date : / /2019 Enrolment No. LL/1012

CERTIFICATE

This is to certify that thesis entitled **"COMPARATVE STUDY OF CONVENTIONAL AND BIODYNAMIC COMPOST ON PERFORMANCE OF ORGANIC CHICKPEA"** submitted in partial fulfilment of the requirement for the degree of **“Master of Science in Agriculture (Agronomy)”** of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola is a record of bonafide research work carried out by **BAYSKAR AKSHAY SATISHRAO** under my guidance and supervision.

The subject of the thesis has been approved by the Student’s Advisory Committee.

Place : Akola
Date : / /2019

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THESIS APPROVED BY THE STUDENT’S ADVISORY COMMITTEE INCLUDING EXTERNAL EXAMINER (AFTER VIVA–VOCE)

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(D) Abbreviations

%	:	Per cent
@	:	At the rate of
^0C	:	Degree Celsius
$^{-1}$or /	:	Per
A	:	Actual
BD	:	Biodynamic compost
B:C	:	Benefit to cost
BSH	:	Bright sunshine hour
CD	:	Critical Difference
Cm	:	Centimeter
CRF	:	Cumulative Rainfall
COC	:	Cost of cultivation
DAS	:	Days after sowing
dm^2	:	Decimeter square
e.g.	:	For example
et al.	:	Et alia (and others)
EVP	:	Evaporation
Fig.	:	Figure
FYM	:	Farm yard manure
G	:	Gram
GM	:	General Mean
GMR	:	Gross monetary returns
Ha	:	Hectare
Hrs	:	Hours
i.e.	:	that is
K	:	Potash
K_2O	:	Potassium oxide
Kg	:	Kilogram
Kmph	:	Kilometer per hour
L. ha	:	Lakh hectares
LAI	:	Leaf area index
M	:	Meter
Max.	:	Maximum

Met	:	Meteorological
Min.	:	Minimum
Ml	:	Milliliter
Mm	:	Millimeter
MSL	:	Mean sea level
Mt	:	Metric tones
MW	:	Meteorological week
N	:	Nitrogen
NMR	:	Net monetary returns
No.	:	Number
NS	:	Non significant
P	:	Phosphorus
Q/q	:	Quintal
RDF	:	Recommended Dose of Fertilizer
RF	:	Rainfall
RH	:	Relative Humidity
`.	:	Rupees
SE (m)+	:	Standard Error of Mean
Sig.	:	Significant
t	:	Tonnes
VC	:	Vermicompost
Viz.	:	Namely
WS	:	Wind speed
Wt.	:	Weight

(F) Thesis Abstract

a)	**Title of the thesis**	:	**"COMPARATIVE STUDY OF CONVENTIONAL AND BIODYNAMIC COMPOST ON PERFORMANCE OF ORGANIC CHICKPEA"**
b)	**Full name of student**	:	**BayskarAkshaySatishrao**
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ABSTRACT

The present investigation entitled, “Comparative study of conventional and biodynamic compost on performance of organic chickpea”, was conducted during *rabi*2017-18 on the field of Agronomy farm section, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soil

of experimental plot was clayey in texture. It was low in available nitrogen and phosphorus and medium in organic carbon, high in available potassium and alkaline in reaction. The experiment was laid out in randomized block design with seven treatments and three replications. Treatments consisted of application of compost viz., Control (T_1), BD compost 5 t ha^{-1} (T_2), T_2 + Soil conditioner 500 (T_3), T_2 + Soil conditioner 501 (T_4), T_2 + Soil conditioner 500+ 501 (T_5), FYM 5 t ha^{-1} (T_6) and Vermicompost 2.5 t ha^{-1} (T_7). Chickpea was sown on 6th November 2017 and harvested on 22nd February 2018.

The differences in growth character were not significant at 20 DAS. As crop in advanced in age, significant difference from 40 DAS were observed and continue to be significant till harvest. Growth attributes *viz.,* plant height, number of leaves, leaf area, number of branches, dry matter accumulation and canopy spread were maximum with treatment of Vermicompost application 2.5 t ha^{-1} (T_7) which was at par with T_2 + soil conditioner 500 + 501 (T_5).

Yield attributes and yield were recorded maximum with treatment Vermicompost 2.5 t ha^{-1}(T_7) which was at par with T_2 + soil conditioner 500 + 501(T_5). However, differences were non significant with 100 seed weight.

Among chemical properties of soil pH, EC, organic carbon and available NPK significantly influenced by different treatment. The significantly lowest pH, EC and highest organic carbon were found in Vermicompost 2.5 t ha^{-1}. Available NPK was found maximum in treatment Vermicompost 2.5 t ha^{-1}.

Considering the economics of organic chickpea production gross monetary return, net monetary return and benefit cost ratio was profitable with Vermicompost 2.5 t ha^{-1} than any other treatment.

CHAPTER I

INTRODUCTION

1.1 Background Information

Pulses are an integral part of many diets across the globe and they have great potential to improve human health, conserve our soil, protects the environment and contributing to global food security. They are rich in protein and fit well in various cropping system. India is largest producer of pulses contributing 25 per cent of total global production and 27 per cent of world consumer and importer of 14 per cent of pulses in the world. Pulses accounts for around 20 per cent of area under food grain contribute around 7-10 per cent of global food production in the country (Dixit *et al*. 2016)

Chickpea (*Cicer arietinum* L.) is known by its different names like Bengal gram in English and Chana in Hindi. It is eaten fresh as a green vegetable or parched, fried, roasted, or boiled seeds. Dal (split chickpea without seedcoat) and flour are used extensively in India as a thick soup for making breads. Sprouted seeds are eaten as a vegetable or added to salads. Young seedlings and green pods are also eaten. Chickpea seeds may be milled or directly used for animal feed. Leaves yield an indigo like dye. Acid exudates from the leaves can be used as a medicine or used as vinegar. Chickpea seeds contain 21% starch, which is suitable for textile sizing, giving light finish to silk, wool and cotton cloth (Duke, 1981).

The use of organic manure has been the traditional means of maintaining soil fertility. Most of organic compost provide a balance sources of nutrients for crops. Compost has a great influence on plant growth like any other commercial fertilizer. These compost contain in small amount of nutrients, therefore the quantity requirement of these organic sources is more to fulfil the crop needs. Besides, the major nutrients, compost also contain traces of micro-nutrients and also provide food for soil microorganisms. This increases activity of microbes which help to convert unavailable plant nutrient into available and fixing the atmospheric nitrogen (Borey, 2016).

The area under chickpea in India was 9.54 million hectares with production of 9.08 million tones with an average productivity of 951 Kg ha^{-1} in 2016-17 (Anonymous 2017).

1.2 Importance and needs of study

Chickpea *(Cicer arietinum* L.) is the major food legume. It belongs to family Fabaceae (Leguminosae), sub family faboideae, genus *Cicer* and species *arietinum.* Nutritionally, it is an importance source of protein in vegetarian diet and become more important to mitigate the problem of protein energy malnutrition (Prasad, 2012). In addition to having high protein content (20 - 22%), chickpea is rich in fiber, minerals (phosphorus, calcium, magnesium, iron and zinc) and β-carotene. Its lipid fraction is rich in unsaturated fatty acids. Chickpea crop meets 80% of its nitrogen (N) requirement from symbiotic nitrogen fixation and can fix up to 140 kg N ha^{-1} from atmosphere. It leaves a substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improve soil health. Because of its deep tap root system, chickpea can withstand extended periods of drought by extracting water from deeper layers of the soil. The south east of Turkey adjoining Syria as possible centre of origin of chickpea based on the presence of closely related annual species of *Cicer reticulatum.* Botanical and archaeological evidence show that chickpea were first domesticated in Middle East and are cultivated in India, middle east and Ethiopia since antiquity. Brought to new world, it is now important in Mexico, Argentina, Chile, Peru and Australia. Wild species are most dominant in Turkey, Iran, Afghanistan and Central Asia (Duke, 1981).

The main objective of vermicomposting is to develop a sustainable agriculture system, which conserves environment, maintain soil fertility and ensures adequate food production. Vermicompost is the method of using earthworms to transform organic waste into nutrient rich compost. Soil earthworms play an important role in agriculture, it decomposes dead organic litter by consuming them and release as castings. The earthworms accelerate decomposition of plant litter and organic matter and improve soil fertility by releasing mineral elements in the forms that are easily uptake by plants (Curry, 1987).The passage of soil through earthworm promote growth of bacteria and actinomycetes, the latter thrive in presence of earthworm and their content in casts is more than 6 times that original soil. Earthworm casts are rich source of micronutrient, enzyme, antibiotics and growth earthworm (Prasad *et al.* 2014).

Biodynamics is a method of agriculture which seeks to actively work with the health gaining forces of nature. It is the oldest non-chemical agriculture movement. In a nutshell, biodynamic can be understood as a combination of "biological dynamic" agriculture practices. "Biological" practices include a series of well-known organic farming techniques that improve soil health. "Dynamic" practices are intended to influence biological as well as metaphysical aspects of the farm (such as increasing vital life force), or to adapt the farm to natural rhythms (such as planting seeds during certain lunar phases). The original biodynamic preparations are numbered (500-508). The BD 500 preparation (horn manure) is made from cow manure (fermented in a cow horn that is buried in soil for six months through autumn and winter). The BD 501 preparation (horn-silica) is made from powdered quartz (packed inside a cow horn and buried in the soil for six months through spring and summer). The next six preparations, BD 502-507 are used in making compost. Finally, there is BD preparation 508 which is prepared from the silica-rich horsetail plant *(Equisetum arevense)* and used as a foliar spray to suppress fungal diseases in plants. Biodynamic compost is a fundamental component of biodynamic method it serves as a way to recycle animal manures and organic wastes, stabilize nitrogen, build soil humus and enhance soil health. Biodynamic compost is unique because it is made with BD preparations 502-507. Biodynamic farming is practiced on a commercial scale in many countries and is gaining wider recognition for its contributions to organic farming, food quality, community supported agriculture and qualitative tests for soils and composts from a practical view point biodynamics is proven to be productive and yield nutritious, high quality foods (Steve Diver, 1999).

Farmyard manure provides all essential plant nutrients including micronutrients and it also improves soil physical, chemical and biological environment of soil for favorable crop growth and yield. It is also known to accelerate the respiratory process that increase cell permeability and hormonal growth action or by combination of all these processes, it is the most useful organic manure as organic matter is provided from various animal wastes (Ugale, 2014).

A strong and prosperous agriculture necessary for economic growth and development of country. Agriculture is one of oldest and most prospective profession of human civilization whose prosperity depends on soil organic status. Till early 1960, the country as a whole practiced conventional agriculture both production and production systems had inputs solely from cultural operations, including crop rotations, organic farming etc. The entire process of crop production underwent sea change after the introduction of high yielding varieties and birth of green revolution. The success of green revolution was historical and its very success was solely based on high input agriculture that included improved irrigation, increased frequency of irrigation, high inorganic fertilization, and heavy application of pesticides. The subsistence agriculture changed to market based agriculture. Crop rotations became meaningless. Organic farming lost relevance to give space to intensive agriculture. Only a few crops such as wheat and paddy occupied both acreage and space. There is absolutely no doubt that the production and productivity of the food grains increased many folds and the nation achieved self-sufficiency and rather became exporter. The continuous intensive cropping system with only a couple of crop species supported by intensive and indiscriminate use of inputs (irrigation, inorganic fertilizers, pesticides) created problems such as disturbed soil fertility, residue in soil, feeds, foods, pollution of every aspect and sphere of agro ecosystems, recurrence, resurgence and resistance in pest etc. The ecology was disturbed, natural equilibrium as established by nature was disrupted with respect to flora and fauna and the ecosystems became harmonious. All these created alarming situations. Today the priority is not only to produce more and more food grains but also to sustain them. This gave birth to the concept of sustainable agriculture, rather sustainable growth of agriculture.

India is the largest producer, consumer and importer of pulses. Pulses production in India is about 19 million tons, every year India is importing about 3-4 million tons of pulses to meet its annual demand of 22-23 million tons**.** In changing climate scenario and decreasing water and land resources, the organic farming is option to achieve to production and productivity sustainably.

In the rapid pace of development we have inflicted serious damage to natural resource. The increase in awareness of the effect of in discriminate use of artificial input in agriculture has lead to adoption of organic and biodynamic farming as an alternative method for conventional farming

In the present investigation an attempt has been made to study the "Comparative study of conventional and biodynamic compost on performance of organic chickpea**"** at field of Agronomy Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with following objectives

1.3 Objectives of study

1. To study the effect of conventional and biodynamic compost on growth, yield and quality of chickpea
2. To asses impact of conventional and biodynamic compost on chemical and biological properties of soil
3. To work out economics of organic chickpea production

1.4 Scope and Limitations

Use of chemical fertilizers has increased crop yield, but caused many environmental problem including soil, air and water pollution and finally human health hazards and making the crop productivity unsuitable. There is need to reduce the ill effects of chemicals on human and environmental health. In these direction several efforts such as integrated arable farming system, low input or organic farming are attempted on different parts of the world. Organic farming production system aims at promoting and enhancing agro-ecosystem health, biodiversity, biological cycles and soil biological activities. Management of soil organic matter is very important to maintain a productive organic farming system.

1.4.2 Limitations

1. Compost has low content of major nutrients in comparison with chemical fertilizer and required in large quantity for crop production.
2. Compost quality and nutrient status depend upon species of crop residue, size of particles and C:N ratio, microbial decomposing culture and method of decomposition used.
3. If compost or organic nutrient source input purchased from marketed the cost of cultivation increases. Production of compost some what laborious and time consuming method.
4. Nutrients present in the compost are not available to crops immediately because due to slow releasing activity.

1.5 Hypothesis

The application of organic sources *viz*., FYM, vermicompost, biodynamics and other non-monetary inputs are very well to know to improve the physical, chemical, and biological properties of soil. These organic sources contain balance nutrient and capacity to release fixed nutrient which required by crops. External input in farming deteriorate soil health but also increases the cost of input. Available biomass of crop should utilized as source of nutrient in the form of different component. Thus the hypothesis is to utilize available crop residue in the form of quality compost and reduced cost of cultivation and produced nutritional food.

CHAPTER II

REVIEW OF LITERATURE

In this chapter an attempt has been made to review the a research work reported on "Comparative study of conventional and biodynamic compost on performance of organic chickpea''.

Information available from review is presented under following objectives

1. To study the effect of conventional and biodynamic compost on growth, yield and quality of chickpea
2. To asses impact of conventional and biodynamic compost on chemical and biological properties of soil
3. To work out economics of organic chickpea production

2.1 Effect of different compost on growth attributes

Muscolo *et al*. (1999) reported that vermicomposts are comprised of large amounts of humic substances, some of the effects of which on plant growth are similar to those of soil-applied plant growth regulators.

Atiyeh *et al.* (2000) concluded that vermicompost tended to be higher in nitrate which is more available of nitrogen to promote better growth and yield compare to conventional compost was higher in ammonium.

Asewar *et al.* (2003*)* founded that the application of vermicompost (@ 3 t ha^{-1}) increased the growth characters, plant height and number of branches per plant in chickpea compare different level of vermicompost.

Siag and Yadav (2004) reported the effect of vermicompost significant increase in seed yield was observed by the application of vermicompost up to 2 t ha^{-1} owing to increased secondary branches $plant^{-1}$, pods $plant^{-1}$ and seed index.

Jat and Ahlawat (2006) carried out at field experiments at the Indian Agricultural Research Institute, New Delhi and reported that application of vermicompost @ 3 t ha^{-1} to chickpea improve dry matter accumulation (20 g $plant^{-1}$) over no vermicompost (19.62 g $plant^{-1}$).

Rinva and Singh (2006) reported a significant increase in number of tillers of wheat with the application of vermicompost @ 10 t ha^{-1} in comparison to FYM 10 t ha^{-1}.

Miceli *et al.* (2008) reported that the number of leaves, stem diameter and stem height of maize increases 0.10, 0.29 and 0.15 fold respectively, in peat moss amendment with addition of vermicompost.

Singh and Prasad (2008) observed the application of vermicompost at 2 t ha^{-1} resulted in higher dry matter (35.57 g $plant^{-1}$), dry weight of nodules $plant^{-1}$ (55.4 mg), number of pods $plant^{-1}$(51.79), seed weight $plant^{-1}$ (14.05 g) and grain (19.09 q ha^{-1}) and straw yields (22.99 q ha^{-1}) of chickpea.

Kausale *et al*. (2009) revealed that application of farm yard manure @ 10 t ha^{-1} recorded higher dry matter accumulation $plant^{-1}$ in groundnut compared to FYM @ 5 t ha^{-1} in the clay soils of Navsari (Gujarat).

Gopinath *et al*. (2010) found that the fresh and dry matter yield of cowpea were higher when soil was amended with vermicompost than with biodigested slurry and also reported that the humic acid in vermicompost had positive effect on growth of maize plants as has been found in green house experiments.

Shete *et al.* (2010) revealed that application of FYM @ 5 t ha^{-1} to green gram recorded significantly higher plant height, number of branches $plant^{-1}$ and dry matter accumulation as compared to the treatment with no FYM in region of Navsari (Gujarat).

Joshi *et al*. (2013) reported that the application of vermicompost (@ 20 t ha^{-1}) in wheat recorded significantly higher plant height (76 cm), stem diameter (0.24 cm), number of leaves per plant (6.4), number of spikes per plant (4) and spike length of wheat crop (13.8 cm) over control (55 cm, 0.19 cm, 4, 2 and 8.8 cm, respectively).

Patil *et al.* (2014) result show that the growth attributes of pigeonpea *viz.*, plant height, number of branches plant^{-1}, number of compound leaves, leaf area plant^{-1} significantly increased due to the application of application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1 t ha^{-1} + two times jeevamrut @ 500 lit. ha^{-1} was predominant on control.

Singh *et al*. (2014) reported that highest growth parameters like plant height, branches plant^{-1}, dry weight plant^{-1} were significantly recorded under vermicompost (2 t ha^{-1}) than FYM (5 t ha^{-1}), neem cake (0.4 t ha-1), *Trichoderma* seed treatment and control in chickpea.

Rahevar *et al.* (2015) concluded that application of FYM @ 5 t ha^{-1} significantly increased the plant height and dry matter production at 30 DAS, 60 DAS and at harvest in summer groundnut than unmanured crop at Navsari (Gujrat).

Degwale (2016) concluded that application of vermicompost @ 5 t ha^{-1} led to maximum leaf number, leaf area index and the highest bulb dry matter percent of garlic as compare to control.

Yadav *et al*. (2017) concluded that application of vermicompost 2 t ha^{-1} recorded significantly tallest plant height (54.70 cm plant^{-1}) and dry matter accumulation (18.61 g plant^{-1}) as compared to cow urine and control.

2.2 Effect of different compost on root studies

Cannelas *et al.* (2002) reported that humic acid extracted from vermicompost has been to promote physiological changes in plant roots including a greater number sites of lateral root emergence and greater total root area.

Bajracharya and Rai (2009) resulted an encouraging effect of vermicompost application on root length and biomass dry weight of chickpea when vermicompost was applied in equal ratio with soil (5 kg each pot^{-1}) and 10:20:15 kg N: P_2O_5:K_2O kg ha^{-1}.

Singh *et al.* (2014) reported that nodules plant^{-1}, nodule dry weight plant^{-1} were significantly recorded under vermicompost (2 t ha^{-1}) than FYM (5 t ha^{-1}), neem cake (0.4 t ha^{-1}), *Trichoderma* seed treatment and control.

Hyder *et al*. (2015) reported that the application of vermicompost @ 2.0 t ha^{-1} recorded significantly maximum shoot/root length (217/37 cm) and shoot/root dry weight (140/10.7 g) of tomato as compared to control (168/18.33 cm and 37.3/3.3 g).

Bairwa and Khandelwal (2016) revealed that 100% RDN through vermicompost recorded maximum root length, root width and yield of succeeding carrot crop after bottle gourd at Durgapur (Rajsthan).

Yadav *et al*. (2017) concluded that application of vermicompost 2 t ha^{-1} recorded significantly total number of root nodules (40.73 plant^{-1}), effective root nodules (36.05 plant^{-1}).

2.3 Effect of different compost on yield and yield attributes

Goldstein (1986) found that biodynamically managed fields had greater microbial biomass, respiration and organic matter and longer wheat roots and resulted in 403-605 kg ha^{-1} more grain yield than did organic system.

Asewar *et al. (*2003*)* concluded that the vermicompost (@ 3 t ha^{-1}) application increased the pods plant^{-1}, grain yield and straw yield compared to the different level of vermicompost in chickpea.

Devi and Singh (2005) reported that the vermicompost at 10 t ha^{-1} gave the highest number of pods plant^{-1} (50.77), number of grains per pod (1.30), and grain (23.22 g) and biological (46.69 g) yields plant^{-1} and per hectare (32.09 and 74.58 quintal), respectively.

Jat and Ahlawat (2006) carried out at field experiments at the Indian Agricultural Research Institute, New Delhi, reported that application of 3 ton vermicompost ha^{-1} to chickpea improve grain yield chickpea over control.

Patel *et al.* (2007) reported that application of FYM @ 5 t ha^{-1} along with *Rhizobium* and PSB recorded significantly higher number of pods per plant (28.70) and higher grain (1171 kg ha^{-1}) and straw (1014 kg ha^{-1}) yield in chickpea.

Singh and Prasad (2008) revealed that application of vermicompost @ 2 t ha^{-1} recorded significantly higher total number of pods plant^{-1}, grain yield and straw yield (51.79, 19.09, 22.99 q ha^{-1}, respectively) in chickpea compared to other treatments.

Suhane *et al.* (2008) reported that exclusive application of vermicompost (@ 2.5 t ha^{-1}) in farm wheat crops supported yield better than chemical fertilizers.

Zalate and Padmani (2009) reported that highest plant height of groundnut noticed with application of FYM @ 6 t ha^{-1} was comparable with vermicompost @ 2 t ha^{-1} or castor cake @ 1 t ha^{-1} .

Davari and Sharma (2010) revealed that the application of FYM or vermicompost significantly increased yield attributes of rice over control which led to 23-34% increase in grain yield.

Trivedi *et al.* (2013) reported that integrated use of biodynamic preparation-BD 501 and botanical neem oil resulted not only into the maximum increase in yield attributes and yield but also significantly reduced the disease incidence of black gram under organic production system.

Bhatia *et al.* (2012) reported that the grain yield (4048 kg ha^{-1}) and straw yield (6192 kg ha^{-1}) of wheat crop were recorded higher with the application of vermicompost @ 10 t ha^{-1} over control (3798 and 5820 kg ha^{-1}).

Meena (2012) reported that application of vermicompost @ 7.5 t ha^{-1} enhanced the yield both grain as well as seed and yield attributing characters of green gram as compared to control and lower levels of vermicompost and also reported that use of 5 t ha^{-1} of vermicompost and 10 t ha^{-1} of FYM proved equally effective in enhancing the yield and yield attributing characteristics of green gram.

Punam *et al*. (2012) revealed that the combined application of organic manure + BD-500 was found sustainably higher in plant height (42.84 cm) and number of off shoots (7.67) at 30 days after planting and 60 days after planting (62.36 cm) as compared to control (38.85 cm).

Saranraj (2012) reported that application of vermicompost at 5 t ha^{-1} significantly increased yield of tomato (*Lycopersicon esculentum*) (5.8 t ha^{-1}) in farmers fields in Adarsha watershed, Kothapally,(Andhra Pradesh) compared to control.

Jariene *et al.* (2014) reported that combined application of BD preparation (500 +501) was the best among all the treatments for yield parameters and yield of potato. It was found that combination of BD preparation (500 + 501) substantially increased the tuber weight (486 g) and numbers of tubers $plant^{-1}$ (9.30) over control (371 g and 8.25) and application of BD-500 and 501 alone (365 g, 8.31 and 37 g, 8.35, respectively).

Joshi *et al*. (2013) reported that the application of vermicompost @ 20 t ha^{-1} was recorded significantly higher yield of wheat (1258 kg $acre^{-1}$) over control (792.5 kg $acre^{-1}$).

Singh *et al*. (2014) reported that the higher values of yield attributes *viz*., number of pods $plant^{-1}$, number of seeds pod^{-1} and 100-seed weight significantly were recorded with application of vermicompost (2 t ha^{-1}) than the other treatments in chickpea.

Gudadhe *et al.* (2015) revealed that chickpea registered significantly higher seed yield in 10 t FYM ha^{-1} + RDF and it was at par with 100% RDN through vermicompost.

Khan *et al*. (2015) reported that the application of vermicompost 6.0 t $ha^{–1}$ to cowpea recorded significantly higher seed yield (14.25 q $ha^{–1}$), straw yield (24.75 q $ha^{–1}$) and biological yield (39.00 q $ha^{–1}$) compare to different level of vermicompost under climatic condition of Gujarat.

Mathukia *et al.* (2015) results revealed that application of FYM (2.5 t ha^{-1}) and vermicompost (0.625 t ha^{-1}) recorded significantly higher pod yield (1533 and 1413 kg ha^{-1}) and haulm yield (3146 and 3288 kg ha^{-1}) of groundnut as compared to RDF at Junagadh (Gujarat).

Barod *et al*. (2016) reported that significantly higher husked and dehusked cob yields (4.43 tha^{-1} and 2.15 t ha^{-1}, respectively) were obtained with the application of N through vermicompost as compared to N applied through leaf compost, FYM and fertilizer at IARI (New Delhi).

Degwale (2016) concluded that application of vermicompost @ 5 t ha^{-1} led to maximum mean clove weight, mean bulb weight, fresh biomass yield and total bulb yield of garlic as compare to control.

Yadav *et al*. (2017) concluded that application of vermicompost 2 t ha^{-1} recorded significantly maximum number of pods (50.12 plant-1), seed yield (1916 kg ha-1) and haulm yield (2998 kg ha-1) as compared to cow urine and control.

Verma *et al*. (2018) reported significantly higher number of grains ear^{-1} and yield (grain and straw) of wheat was recorded with FYM at @ 7.5 t ha^{-1}+ VC @ 3 t ha^{-1}, being at par with vermicompost @ 6 t ha^{-1} and superior to rest of the treatments.

2.4 Effect of different compost on chemical properties of soil

Reinken (1987) conducted an experiment for 8 years (followed biodynamic and conventional rules) at the experimental station Auweiler, D-5000, Cologue and reported that biodynamic growing resulted in an improvement of some soil properties, e.g. increase of organic matter content, the pH value and improvement of earthworm activity, as compared to conventional growing.

Debosz *et al.* (2002) reported that organic matter through the application of vermicompost increased the bioavailability of phosphorous in the soil effecting plant growth in potato cropping.

Sharma and Vyas (2002) conducted field experiment at Avikanagar (Rajasthan) and reported that incorporation of FYM @ 10 t ha^{-1} to wheat substantially improved the physico-chemical properties of soil as compared with rest of the treatments.

Kademani *et al.* (2003) founded that highest available N, P, and K in soil was noticed in vermicompost treated plot with 245, 36.78, 528.4 kg ha^{-1} respectively followed by FYM treatment (241, 35.01, 522.5 N, P, K kg ha^{-1}).

Katkar *et al.* (2005) revealed that the organic carbon has slightly increased with application of FYM @ 5 t ha^{-1} and also reported that at same rate of FYM application significantly decreased soil pH and electrical conductivity.

Ghuman and Sur (2006) reported that application of FYM @ 18 t ha^{-1} recorded lower pH (7.3) over FYM applied @ 6 t ha^{-1} (7.4) and also observed that at same rate of application of FYM increased organic carbon content from 0.29 % to 0.33 %.

Ansari (2008) reported that reduction in electrical conductivity and decrease in pH of soil was observed when vermicompost use @ 6 t ha^{-1} compared to control.

Gopinath *et al*. (2010) reported that the use of vermicompost has been recognized as an effective means of increasing crop yield through improved soil physical, chemical and biological properties.

Rajkhowa *et al.* (2013) resulted that vermicompost would not only increase organic carbon status of the soils but also increase the soil water holding capacity thus improve the soil and crop production sustainable and also reported that higher uptake of nitrogen and phosphorus in seed and stover (11.4, 11.2, 1.4 and 1.2 kg ha^{-1}, respectively) of green gram due to the application of vermicompost either alone or in combination with chemical fertilizers.

Singh *et al.* (2014) reported that the significantly maximum organic carbon (0.62%) was accrued on application of vermicompost at 2 t ha^{-1} in field pea, while the least (0.56%) was noticed with control.

2.6 Effect of different compost on nutrient content, uptake and protein percentage

Jat and Ahlawat (2006) carried out at field experiments at the Indian Agricultural Research Institute, New Delhi, and reported that application of 3 ton vermicompost ha^{-1} to chickpea improve grain protein in chickpea over control.

Singh and Prasad (2008) carried out field experiment at Kanpur, results revealed that application of vermicompost @ 2 t ha^{-1} resulted in higher total N and P (86.32 and 9.88 kg ha^{-1}, respectively) uptake by chickpea grown in sandy loam soil.

Gopinath *et al.* (2010) found that increased of 56.14% of protein in cowpea pods from vermicompost (26.7 %) treated plots compared to inorganic (17.1%) treated plots.

Davari *et al*. (2012) reported that application of vermicompost (equivalent to 60 kg N ha^{-1}) significantly increased uptake of N (64.2 g ha^{-1}), P (12.1 g ha^{-1}) and K (15.4 g ha^{-1}) by wheat grain over the control (37.1, 7.2 and 9.0 g ha^{-1}). The increase in nutrient uptake may be due to an increase in available N, P and K contents in the soil and improved soil structure for higher uptake of nutrients.

Singh *et al.* (2014) reported that significantly the highest nitrogen, phosphorus and potassium by grain and straw was observed under vermicompost at 2 t ha^{-1} followed by FYM at 5 t ha^{-1}, neem cake, *Trichoderma* seed treatment and control in chickpea.

Khan *et al*. (2015) reported that the progressive increase in vermicompost levels upto 6.0 t ha^{-1} significantly higher the protein content in seed and effective root nodules over the lower vermicompost levels.

Barod *et al*. (2016) reported that significantly higher protein concentration was obtained with the application of N through vermicompost at IARI (New Delhi).

Verma *et al*. (2018) reported significantly higher protein content and protein yield of wheat when manuring at @ 7.5 t FYM + 3 tha^{-1}VC or 6 t ha^{-1} VC were equally effective treatments with regard to protein content and protein yield**.**

2.7 Effect of different compost on Economics.

Sharma *et al.* (2007) conducted the experiment to study the response of chickpea to vermicompost with and without PSB and phosphorus nutrition and result showed that among different bio-organic treatments, FYM+PSB produced the generated maximum net profit worth `. 29736 ha^{-1}.

Peyvast *et al.* (2008) concluded that vermicomposting can be an economical alternative for livestock waste management.

Davari and Sharma (2010) revealed that the application of FYM or vermicompost significantly increased net profit of rice over control which is led to 14-18% increase in net profit.

Trivedi *et al*. (2013) observed that the maximum net returns `. 23966 $ha^{-1}$ was obtained in spray with BD 501 and lowest net returns was obtained from untreated control (` 17356 ha^{-1}). The maximum B: C ratio 2.24 was obtained in spray with silicon BD and lowest B:C ratio was obtained from untreated control (1.55).

Singh *et al.* (2014) reported that highest gross return was highest under vermicompost (2 t ha^{-1}) followed FYM neem cake, *Trichoderma* and control in chickpea.

Khan *et al.* (2015) reported that the application of vermicompost 4.0 t ha^{-1} maximum and significantly higher the net returns over other treatments and remained at par with 6.0 t ha^{-1} of vermicompost.

Kumar *et al.* (2017) the crop economics results concluded that B:C ratio of ragi is 1.08 in case of organic farming which is more than the conventional farming of 0.72. Likewise, in case of maize B:C ratio is 1.37 in organic farming which is a little bit higher than that of conventional farming of B:C ratio 1.12.

Sharma *et al.* (2017) reported application of enriched compost @ 4 t ha^{-1} + BD 500 + BD 501 + *Azotobacter* + PSB also resulted in maximum net return (52704 ha^{-1}), B: C ratio (3.84) in sesame.

CHAPTER III

MATERIAL AND METHODS

A field experiment entitled "Comparative study of conventional and biodynamic compost on performance of organic chickpea" was carried out during *rabi* season of 2017-2018. The details of experimental procedure adopted, material used and methods adopted during the course of present investigation are described in this chapter.

3.1 Basic resource information

3.1.1 Experimental site

The present field experiment was conducted at Agronomy Farm Section, Dr.PDKV, Akola during *rabi* season 2017-2018. The field selected for conducting the experiment was fairly uniform and leveled.

3.1.2 Cropping history of the experimental site

The experimental field in which the present experiment was conducted during the *rabi* season of the year 2018, cropping history of the experimental field during last three years i.e. from 2015-16 to 2017-18 is given in Table 1.

Table 1. Cropping history of the experimental site

Year	Season		
	Kharif	***Rabi***	***Summer***
2015-16	Soybean	Chickpea	Sesame
2016-17	Soybean	Chickpea	Sesame
2017-18	Soybean	Present investigation	-

3.1.3 Soil characteristics

In order to determine the physical - chemical properties of the soil, the soil samples from 0 to 30 cm depth were collected randomly from different plots. Composite samples were analysed for physico-chemical properties. The soil of experimental plot was clayey in texture. It was low in available nitrogen and phosphorus and fairly rich in available potassium and slightly alkaline in reaction. The method adopted to determine the important initial properties and the result obtained have been presented in Table 2.

Table 2. Physico-chemical properties of experimental site

Sr. No.	Particulars	Composition	Analytical method adopted
A.	**Mechanical Analysis**		
1.	Sand (%)	11.7	Bouyoucos Hydrometer Method (Piper, 1966)
2.	Silt (%)	34.0	
3.	Clay (%)	54.3	
4.	Texture class	Clayey	
B.	**Chemical Analysis**		
1.	pH	8.26	By glass electrode pH meter method (Jackson, 1967)
2.	EC (dS m^{-1})	0.30	Electrical conductance method (Jackson, 1967)
3.	Organic carbon (g/kg)	5.00	Walkley and black wet digestion method (Jackson, 1967)
4.	Available Nitrogen (kg ha^{-1})	210.63	Alkaline potassium permanganate method (Subbaiah and Asija, 1959)
5.	Available Phosphorus (kg ha^{-1})	13.86	Olsen's method (Jackson, 1967)
6.	Available Potassium (kg ha^{-1})	309.54	Flame photometer (Jackson, 1967)

3.1.4 Weather and climatic conditions

Weather and climatic conditions

Akola is situated at 307.42 meters above from mean sea level with 20.42^{0}N latitude and 72.02^{0}E longitude. The climate of the place is semi-arid and characterized by three distinct seasons *viz*., hot and dry

Table 3: Weekly weather data for the year 2017-2018 recorded at Meteorological Observatory, Department of Agronomy, Dr. PDKV, Akola.

Normal 1971-2010 Actual -2017

met. Weeks	Dates	T MAX (oC)		T MIN (oC)		BSH (hrs)		WS (km hr^{-1})		RH I (%)		RH II (%)		Evap (mm)		RF (mm)		CRF (mm)	Rainy Days	
		N	A	N	A	N	A	N	A	N	A	N	A	N	A	N	A		N	A
44	29-4 Nov	32.7	32.7	16.0	14.0	8.4	8.5	4.1	0.6	73	82	32	26	5.3	5.9	2.3	0.0	518.1	0.2	0.0
45	5-11	32.3	31.6	15.2	14.7	8.4	8.5	3.9	1.0	71	81	32	28	5.1	5.4	3.0	0.0	518.1	0.2	0.0
46	12-18	31.6	31.0	14.6	13.7	8.3	7.9	3.9	0.4	73	79	32	37	4.8	4.9	5.3	0.0	518.1	0.2	0.0
47	19-25	31.0	31.8	13.3	17.9	8.4	5.3	3.7	0.9	72	84	30	40	4.6	4.6	7.7	0.0	518.1	0.3	0.0
48	26-2 Dec	30.5	30.6	12.8	11.2	8.4	8.2	3.6	0.9	71	79	32	19	4.4	5.4	5.5	0.0	518.1	0.3	0.0
49	3-9	30.0	29.7	11.9	14.5	8.4	5.6	3.8	1.5	71	78	30	38	4.3	4.8	1.0	0.0	518.1	0.1	0.0
50	10-16	29.6	31.2	10.9	13.7	8.4	7.6	3.6	0.8	71	74	28	27	4.2	5.2	0.8	0.0	518.1	0.1	0.0
51	17-23	29.5	29.8	10.8	10.4	8.5	6.6	3.8	0.8	70	80	29	25	4.1	4.6	0.9	0.0	518.1	0.1	0.0
52	24-31	29.1	29.4	11.1	8.7	8.3	8.2	4.5	1.0	71	72	30	22	4.2	4.3	2.6	0.0	518.1	0.2	0.0
		2018																		
1	1-7 Jan 2018	28.8	29.5	11.0	9.4	8.2	7.5	4.4	0.8	71	74	31	23	4.2	3.8	2.8	0.0	0.0	0.2	0.0
2	8-14	29.3	29.6	11.7	12.3	8.3	7.7	4.4	1.2	71	58	30	23	4.4	5.9	3.3	0.0	0.0	0.2	0.0
3	15-21	30.0	31.3	12.0	12.1	8.6	7.9	4.5	1.3	68	67	28	20	4.9	6.4	0.7	0.0	0.0	0.1	0.0
4	22-28	30.6	29.8	12.0	10.0	8.8	8.3	4.6	1.7	65	57	26	20	5.2	7.3	0.9	0.0	0.0	0.1	0.0
5	29-4 Feb	31.0	32.4	12.6	10.9	8.8	6.9	4.9	1.0	62	59	25	15	5.5	6.7	3.0	0.0	0.0	0.2	0.0
6	5-11	31.4	32.3	12.7	16.0	8.8	3.8	5.0	1.9	59	47	23	20	5.9	7.4	3.7	0.0	0.0	0.3	0.0
7	12-18	32.7	29.9	14.4	14.9	9.0	6.1	5.4	3.9	55	70	22	33	6.6	6.6	0.1	0.7	0.7	0.0	0.0
8	19-25	33.4	35.5	14.5	17.9	9.1	8.0	5.7	1.8	54	48	21	19	7.3	7.4	2.5	0.0	0.7	0.2	0.0
9	26-4 Mar	35.0	37.3	15.7	18.5	9.5	8.1	6.1	1.7	50	40	18	15	8.2	7.6	4.1	0.0	0.7	0.3	0.0
10	5-11	35.9	36.7	17.3	22.1	9.2	6.1	6.1	4.0	46	37	20	20	8.8	8.9	5.2	3.0	3.7	0.3	1.0
11	12-18	37.0	34.7	18.1	20.3	9.1	4.8	6.3	2.5	45	56	18	18	9.2	7.3	2.4	0.4	4.1	0.3	0.0
12	19-25	38.4	37.7	19.3	20.4	9.2	8.6	6.4	3.3	39	36	15	14	10.4	10.2	0.6	0.0	4.1	0.1	0.0

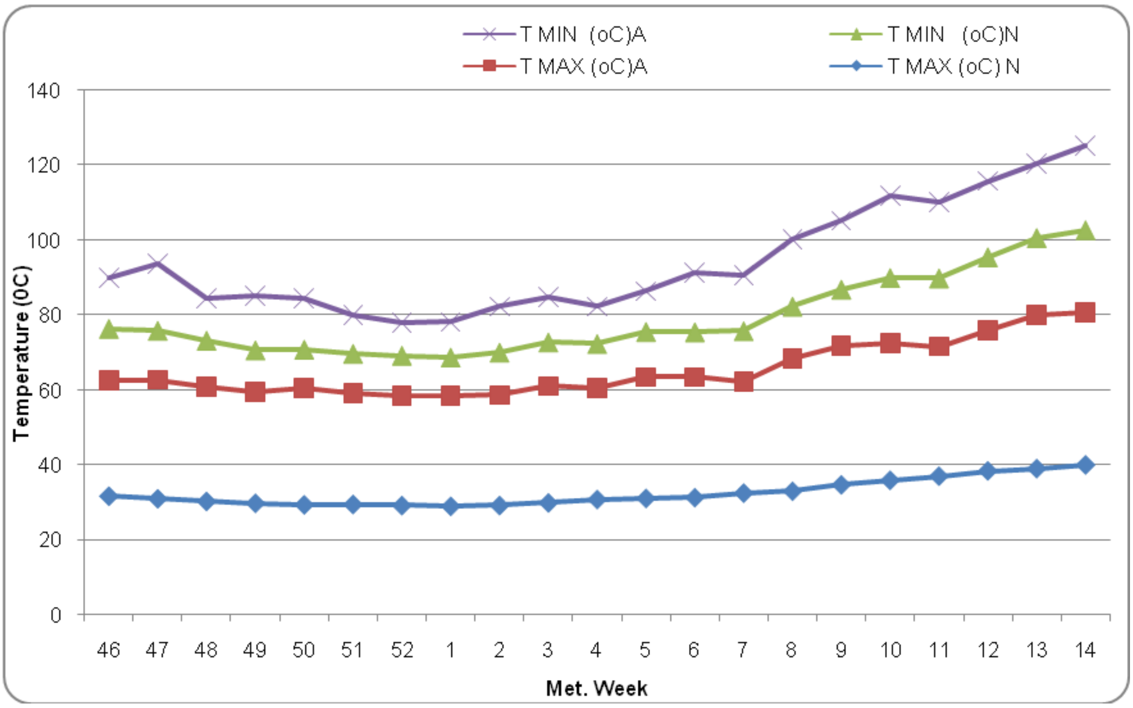

Fig. 1. Weekly maximum and minimum temperature at Akola during crop period

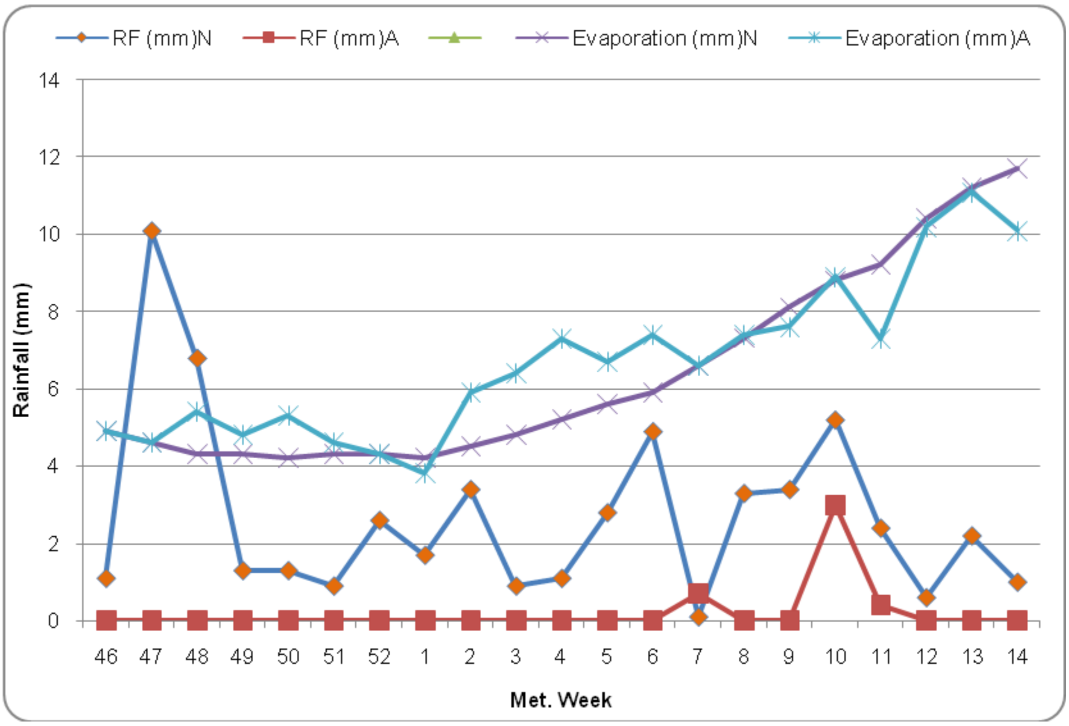

Fig. 2. Weekly evaporation (mm) and rainfall (mm) at Akola during crop period

summer from February to May, warm and rainy monsoon from June to September and moderate cold winter from October to January. The rains are mostly received from south west monsoon with mean annual precipitation (on the basic of last fifteen years) 802 mm and which is generally received in 41 rainy days. During the period of investigation, the average maximum temperature ranged from 40^0C to 45^0C. Almost humidity ranged from 67.5 per cent during morning hours and 30.12 per cent during evening hours.

The meteorological weather data of *Rabi* season for 2017-18 recorded at meteorological observatory, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, is presented along with normal values in Table 4 and graphically depicted in Fig. 1 and Fig. 2.

3.2 Experimental details

3.2.1 Title of Experiment

"Comparative study of conventional and biodynamic compost on performance of organic chickpea.**"** was carried out during *rabi* season of the year 2017-18.

3.2.2 Experimental design and treatment

The present experiment was conducted during the *rabi* season of the year 2017. The experiment was laid out in Randomized Block design. The gross plot size was 5.40 m x 6 m. The net plot size was 4.50 m x 5.60 m Details of the experimental treatments along with symbols used in plan of layout are given in Table 4.

Methodology:

Experimental details:

1.	Name of crop	:	Chickpea
2.	Experimental design	:	Randomized block design
3.	Number of replications	:	03
4.	Number of treatments	:	07
5.	Number of plots	:	21
6.	Plot size	:	Gross: 5.40 m x 6.00 m
			Net: 4.50 m x 5.60 m
7.	Seed rate	:	75 kg ha^{-1}
9.	Variety	:	JAKI-9218
10.	Spacing	:	45 cm x 5 cm
11.	Sowing method	:	Drilling
12.	Season	:	*Rabi* 2017
14.	Location	:	Agronomy Farm Section, Dr.PDKV, Akola.
15.	Date of sowing	:	6^{th} November, 2017
16.	Date of harvest	:	22^{th} February, 2018

Table 4. Treatment details

1	**T_1**	Control
2	**T_2**	BD compost 5 t ha^{-1}
3	**T_3**	T_2 + soil conditioner 500 @75 g ha^{-1}
4	**T_4**	T_2+ soil conditioner 501 @ 2.5 g ha^{-1}
5	**T_5**	T_2 + soil conditioner 500 @75 g ha^{-1} + soil conditioner 501
6	**T_6**	FYM 5 t ha^{-1}
7	**T_7**	Vermicompost 2.5 t ha^{-1}

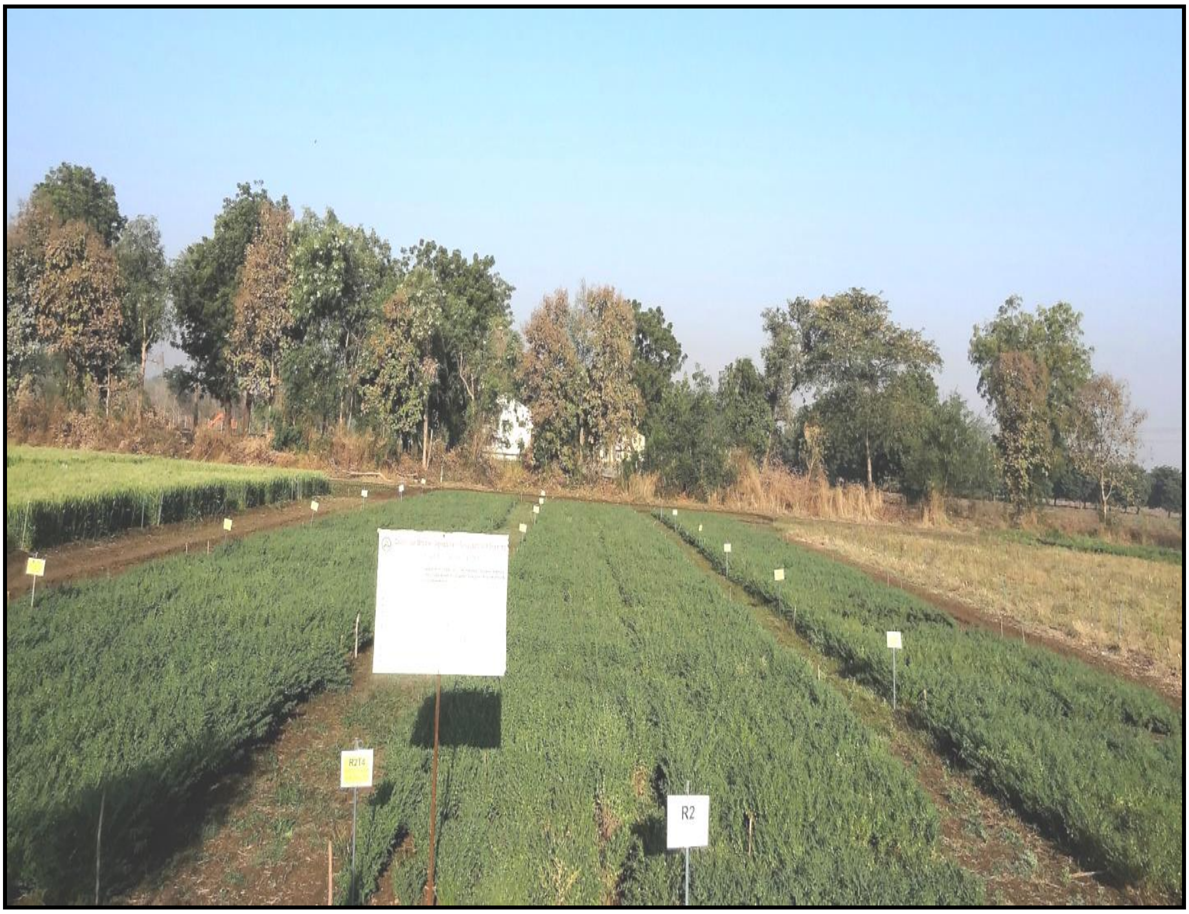

Plate 1: General view of experimental plot

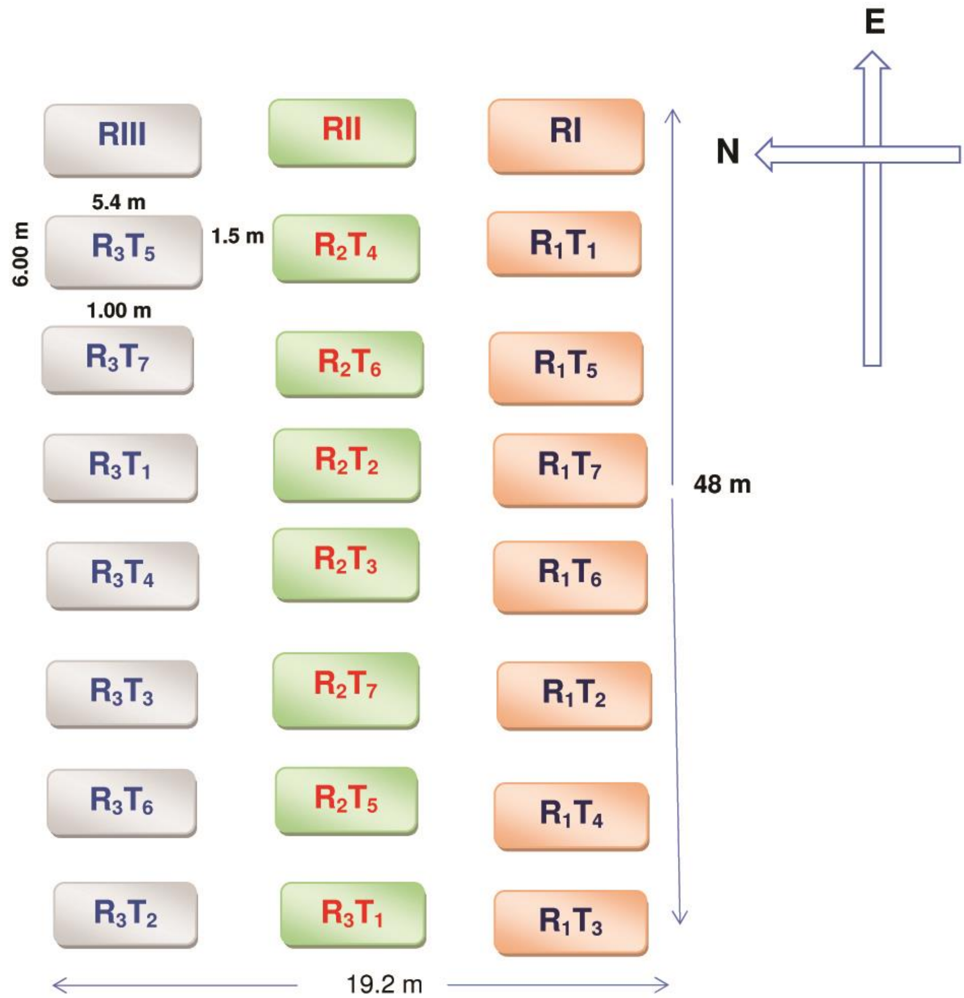

Fig.3. Experimental Layout

3.2.3 Process of preparation vermicompost.

Vermicompost is mostly prepared by peat or heap method. The dimension of heap or pit are 10 x 4 x 2 feet. The length and width can be increased or decreasing depending on the availability of material but depth not more than 2 feet because earthworm activity confined to only 2 feet. Generally, earthworms like to live in shady and moist places and such conditions are conducive for their faster multiplication. Moistened the surface by sprinkling of water. Spread 2-3 inch thick layer of dry leaves or crop residues at base of peat. Again sprinkling some amount of water over layer of dry material. Spread about 1-1.5 feet thick layer of cow dung uniformly over leaves or residues and sprinkled water to make it sufficient moist. The cow dung should not too fresh. It should be at least 10-15 days old because fresh cow dung produce lot of heat and it can kill the earthworms.

Continue the layer up to pile to ground level in case of pit method and upto 2 feet in heap or surface bed method. Protect the worms against natural enemies like ants, lizard, snakes, frog, toads etc. maintained proper moisture and temperature by adding water and turning. At the day of 21th 4000 worms are introduced in to pit without disturbing the pit. Placed gunny bag on it for maintaining moisture through watering.

3.2.4 Process of preparation of Biodynamic compost:

Ingredients: the key ingredient are: (1) dry matter such crop residues, dried leaves (2) green matter (grass, Leaves, weed old plant from garden) cut them as closed as possible to when they are used (3) Manure (cow manure), (4) water, (5) gardener lime, (6) crushed rock dust, (7) wood ash, (8) some old compost and S-9 culture. An ideal minimum size for heap is 1 cubic meter. This is big enough to generates sufficient heat for the heap and gives a reasonable volume of compost.

Making of compost : Commences with dry matter, then manure and then green matter. On green matter sprinkled a small handful of limes. Repeat this layering in the same order, except you alternate the limes with small handful of rocks dust and wood ash. Water the heap as you go, lot of moisture is important. Fresh manure is the best to use, as it spread easily and has more life to add to heap.

When you have use up all your ingredient and it into uniform shapes, the heap will be a cubic squares of one cubic meter heap or a rectangular shapes for larger volumes. Compost preparation 502-507 are then added in order.

Make a circle of 5 holes around the top of heap and then one holes in middle. These holes should be about 50 cm deep. Then insert compost preparations 502-506 within a ball of manure into the holes. The 507 should be stirred for 15 minute in clean water before being applied. Put half down the middles hole and rest is poured over top of entire heap.

Then cover the heap with a thick layer of hay. The heap should heat up with few day and may reach up to 70^0 C. If made properly it will stay hot for a few weeks and then begin to cool off and may still be warm after month. You monitor heap the first months to check its progress. If is too dry, it will need forking or turning, with water added. If it is not hot, it will also need turning to aerate it and most likely more water. The heap should be use after about 3-4 months.

3.2.5 BD 500 Cow horn manure.

It is basically fermented cow dung. It is the basis for soil fertility and the renewal of degraded soils. It is buried in Sept./Nov and lifted in Feb/March. This is the period when the earth is breathing in and comic earth forces are most active (winter).

Materials

- Cow horns
- Fresh cow dung from a lactating cow. Average 50-150 gms dung/horn (depends on horn size).

Preparation process

- Feed cattle with high quality food for two days prior to collecting dung for BD 500 (good green fodder and less protein artificial feed).
- Prepare burial pit: 18 inches deep. Pit area should not be subject to flooding, vigorous root systems or earthworms. BD 500 takes the

character of the soil it is buried in, so good quality earth in the burial pit is essential.

- Collect cow horns – remove any paint.
- Collect fresh dung – reasonably firm.
- Fill cow horns with cow dung in October/November (rather than September due to India's warmer climate).
- Place horns in burial pit, 1 inch apart with base downwards, surround with 50% compost and soil.
- Cover with soil and bury for 4 to 6 months. If the soil is not rich enough, add compost to an extent of 50% to enhance soil quality.
- Keep burial pit soil moist and shaded, at temp of approx. 20ºC and free from weeds and earthworms.
- After 4 months check for dung fermentation. Dig up one horn. If the green cow dung has turned into a dark, smooth earthy smelling humus (BD 500) they are ready to be lifted. Remove the BD 500, use and store. If not, leave them longer.

Application process

Apply when the dew is falling (the earth breathes in) i.e. late afternoon or evening – descending Moon.

- 30 grams BD 500 is enough for application of per acre.
- Take 13 liter of water and added 30 gram of BD 500, Stir it 30 min in anticlock and clockwise wise direction with the help of stick.
- Spray in the late afternoon or evening (just before sunset), when Moon is descending with the help of twinge of neem.
- Spray 4 times a year – during the beginning and after rains, i.e. Feb-May-Nov-Dec.

3.2.6 Method of preparation of BD-501

BD 501 is also known as “cow horn silica” and is made from quartz crystals ground to alum power consistency, stuffed into a cow horn, buried during spring equinox and taken out during autumn equinox. The material was stored in glass bottle. BD 501 spray solution is prepared by dissolving 2.5 g in 40 litre of water in a similar way as that of BD 500.

Within an hour, the mixture was sprayed as a fine mist on the plant foliage (i.e. before 9.00 am). The application dates corresponded to days when moon was opposite to Saturn in the biodynamic calendar.

3.3 Details of cultural operations

The schedule of various field operations carried out during the period of experimentation are presented in Table 6.

3.3.1 Land preparation layout of experiment

The land was prepared with the help of tractor drawn implement. The stubbles of previous crop and weeds were collected followed by harrowing and coarse seed bed is obtained which is most suited for chickpea crop.

3.3.2 Seed treatment

The plot applied with BD compost that Seed of gram treated with S9 culture @ 30 g kg^{-1} and other seed was inoculated with *Rhizobium* and PSB culture @ 250 g 10 kg^{-1} seed just before sowing.

3.3.3 Seeds and sowing

Chickpea seed materials for the present investigation was obtained from the COART, Dr. PDKV, Akola. Sowing was undertaken by drilling method keeping 45 cm distance between two rows while plant to plant distance maintained was 5 cm after moistening the field with irrigation.

3.3.4 Gap filling and thinning

Gap filling was done on 10^{th} day and 21^{st} day of sowing so that single plant was retained per hill at distance of 10 cm to maintain required plant population.

3.3.5 Application of organic manure

Organic manure was applied to all treatments except control before sowing by broadcasting method.

Table 5. Chemical composition of compost

Sr. No.	Organic sources	N (%)	P (%)	K (%)
1	Vermicompost	1.60	0.50	0.86
2	Biodynamic compost	1.12	0.36	0.80
3	FYM	0.50	0.20	0.50

3.3.6 Intercultural operations

Hoeing and hand weeding were undertaken to keep the crop weed free and to keep the soil loose and porous for good aeration, moisture conservation and better establishment of root system. The crops were kept free from weeds up to 45 days after sowing.

Table 6.Schedule of cultural operations

Sr. No.	Field operations	Frequency	Date of operation
I	**Preparatory tillage**		
1	Ploughing	1	26.10.2016
2	Harrowing	1	28.10.2016
3	Stubble collection	1	30.10.2017
4	Layout of experimental plot	1	02.11.2017
II	**Sowing and fertilizer application**		
1	Application of VC, BD and FYM	1	03.11.2017
2	Sowing (Drilling)	1	06.11.2017
III	**Post sowing operation**		
1	Gap filling	1	16.11.2017
2	Hoeing	1	25.11.2017
3	Hand weeding	1	05.12.2017

IV	**Spraying**		
1	B.D- 500	1	5.11.2017
2	B.D.501	1	06.12.2017
3	Dashaparni ark	1	15.12.2017
4	HaNPV	1	26.12.2017
V	**Irrigation**		
1	1st irrigation	-	04.11.2017
2	2nd irrigation	-	09.12.2017
VI	**Harvesting**		
1	Harvesting	1	22.02.2018
2	Threshing	1	25.02.2018

3.3.7 Harvesting and threshing

Harvesting was done manually when the crop showed physiological maturity and the grains were completely matured. The harvesting was done by cutting the plant near to the ground and crop was collected separately and plot borders from each net plot area. The harvested produce kept in plots itself for sun drying and then threshed out and winnowed manually and clean seed obtained. Similarly five observation plants from each plot were harvested separately and taken to the laboratory for post-harvest studies.

3.4 Biometric observations

Five plants were randomly selected treatment wise from each net plot in all replications. The plants were labelled and various biometric observations were recorded periodically after 30 days of interval till maturity of the crop. Observations on yield components were recorded after harvest of crop. Various biometric observations recorded during the period of investigation are given in the Table 7.

Table 7. Details of biometric observation

Sr. No.	Particular	Frequency	Days after sowing (DAS)
A	**Pre harvest observations**		
(a)	**Plant count**		
1	Initial plant count	1	15 DAS
2	Final plant stand	1	At harvest
(b)	**Growth studies**		
1	Plant height (cm)	5	20,40,60,80 DAS and at harvest
2	Number of branches plant^{-1}	5	20,40,60,80 DAS and at harvest
3	Number of functional leaves plant^{-1}	5	20,40,60 and 80 DAS
4	Leaf area plant^{-1} (dm^2)	5	20,40,60 and 80 DAS
5	dry matter accumulation plant^{-1} (g)	5	20,40,60,80 DAS and at harvest
6	Days to 50% flowering	1	-
7.	Canopy spread (cm)	3	30,60 and 90 DAS
(c)	**Root studies**		
1	Root length plant^{-1} (cm)	3	30,60 and 90 DAS
2	Number of nodules plant^{-1}	3	30,60 and 90 DAS
3	Root dry weight plant^{-1} (g)	3	30,60 and 90 DAS
4	Root volume (cm^3)	3	30,60 and 90 DAS
B	**Post harvest observations**		
1	Number of pods plant^{-1}	1	At harvest
2	Weight of pods plant^{-1} (g)	1	At harvest
3	Seed weight /plant (g)	1	After harvest
4	100 seed weight (g)	1	After harvest
5	Seed yield (kg ha^{-1})	1	After harvest
6	Straw yield (kg ha^{-1})	1	After harvest

7	Biological yield (kg ha^{-1})	1	After harvest
8	Harvest index (%)	1	After harvest
C	**Chemical analysis**		
1	Soil pH	2	At initial and final
2	EC (ds m^{-1})	2	At initial and final
3	Organic carbon (%)	2	At initial and at harvest
4	Available N (kg ha^{-1})	2	Before sowing and at harvest
5	Available P_2O_5 (kg ha^{-1})	2	Before sowing and at harvest
6	Available K_2O (kg ha^{-1})	2	Before sowing and at harvest
7	NPK analysis of plant sample	1	At harvest
D	**Quality Study**		
1	Protein Percent in Seed	1	After harvest
E	**Biological properties**		
1	Microbial count in rhizosphere	1	At flowering
D	**Economics**		
1	Cost of cultivation (Rs ha^{-1})	-	After harvest
2	Gross monetary returns (GMR) (Rs ha^{-1})	-	After harvest
3	Net monetary returns (NMR) (Rs ha^{-1})	-	After harvest
4	B : C ratio	-	After harvest

The techniques followed for recording each observation are also described separately where ever felt necessary.

3.4.1 Plant stand

3.4.1.1 Initial plant count and final plant stand

Number of plants per square meter area of each net plot was counted at 15 days after sowing. Likewise, final plants stand also taken just before harvest of the crop.

3.4.2 Growth attributes

3.4.2.1 Plant height (cm)

Five plants in each plot were selected randomly and their height was measured in cm from the base of the plant to the tip of main shoot. The observations were recorded periodically at an interval of 20 days from sowing till harvest of crop.

3.4.2.2 Number of branches plant^{-1}

The numbers of branches plant^{-1} were recorded from the five selected plants and mean number of branches plant^{-1} was worked out.

3.4.2.3 Number of functional leaves plant^{-1}

Observations on number of functional leaves plant^{-1} recorded at the interval of 20 days i.e. 20, 40,60 and 80 DAS. Each twig was discarded from each branch of the plant and recorded as functional leaves of that plant.

3.4.2.4 Leaf area plant^{-1}

Leaf area of each plant is measured by removing each twig from each branch of the representative plant and running it on the leaf area meter (LI-COR Model) with transparent conveyer belt having electronic digital display. Reading of the leaf area meter was recorded as leaf area of the plant in dm^2.

3.4.2.5 Total dry matter plant^{-1}

Observations on total dry matter plant^{-1}recorded at the interval of 20 days i.e. 20, 40, 60, 80 DAS and at harvest.

From each replication and treatment plant were uprooted. Plant samples were washed with tap water in order to remove soil and dust particle if adhered on it. The surface was allowed to soak in dry air. The plant sample was then placed in the big size brown paper bags. The brown paper bags were placed in the rack to allow the samples to dry with open air. After drying the samples on open air the plant sample was finally dried in hot air oven at 65 ^{0}C up to the constant weight achieved. The plant samples were weighed on electronic balance and recorded in gram plant^{-1}.

3.4.2.6 Days to 50 per cent flowering

The number of days taken for 50 per cent flowering from the date of sowing in each treatment was recorded by taking flower initiation in net plot.

3.4.2.7 Canopy spread (cm)

Plant spread exhibit the potential spread of the plant in all the directions. It is specifically measured either in north-south or east- west or both depending on the plant geometry. In present investigation the spread of chickpea plant was measured in both the direction by extending the measuring scale at both the tips at north-south direction without disturbing the plant and thus plant spread was counted and measured in centimeters (cm).

3.4.3 Root Studies

3.4.3.1 Root length plant^{-1}

Root length of each representative plant is measured by uprooting the representative plant from each plot. A light irrigation is given prior to each uprooting and length is measured by using scale of 30 cm.

3.4.3.2 Root weight plant^{-1}

Root weight of each representative plant has been taken by drying the uprooted plants at 30, 60 and 90 DAS. The representative plants were uprooted by above manner, removed roots from stem and allowed to sun drying. The root weight measured by analytical measuring balance.

3.4.3.3 Number of nodules plant^{-1}

Number of root nodules plant^{-1} have been counted by uprooting the representative plant from each plot. A light irrigation is given prior to each uprooting and nodules were counted manually in the interval of 30 days from sowing to the harvest

3.4.3.4 Root volume per plant^{-1}

Root volume of each representive plant is measured by keep a cut root in measuring cylinder which is full with water these measuring cylinder are placed perti plate. The amount of water drop in perti plate is measured in another measuring cylinder. It represents root volume of plant.

3.4.4 Yield attributes and yield studies

Important yield attributing characters were studied after the harvest of crop.

3.4.4.1 Number of pods plant^{-1} and weight of pods plant^{-1}

The pods from the randomly selected five plants were picked and total numbers of pods were counted. The average number of pods plant^{-1} and weight of pods plant^{-1} were estimated.

3.4.4.2 Weight of grains plant^{-1}

All the pods of the selected observation plants were threshed separately and average seed weight plant^{-1} was worked out.

3.4.4.3 Seed index

Hundred seed were counted from representative samples from each net plot and weighted separately. This hundred seed weight was worked out as seed index.

3.4.4.4 Grain yield

The plants harvested from each net plot were threshed, cleaned and seed weight plot^{-1} was recorded separately. The seed yield was then converted into hectare yield (kg ha^{-1}).

3.4.4.5 Straw yield

Straw yield was obtained by deducting the weight of seeds from the biological yield of respective net plot and transformed into per hectare yield (kg ha^{-1}).

3.4.4.6 Biological yield

The plants from each net plot were cut close to the ground, tied into bundles, dried in the sun and their weight was recorded before threshing as per treatments. From per plot yield per hectare yield was worked out.

3.4.4.7 Harvest index (%)

Harvest index of chickpea crop was calculated by using the formula as suggested by Donald (1962).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

3.5 Chemical studies

3.5.1 Soil analysis

Composite soil sample 0-30 cm depth from randomly selected spots in the experimental area was collected before start of experiment during 2016. It was air dried in shade, powdered and analyzed for determination of physical and chemical properties of soil.

Treatment wise soil samples 0-15 cm and 15-30 cm depth from each plot were collected after harvesting of crop. The samples were air dried, powdered and analyzed for estimation of available nitrogen, phosphorous, potassium. Balance sheet of N, P_2O_5 and K_2O was worked by considering initial fertility status and final balance of nutrients in the soil after completion of experimentation. The method adopted for these studies are given below.

3.5.1.1 Soil pH

Soil pH was determined by pH meter after equilibrating soil with water for 60 minutes in the ratio of 1: 2.5 soil water suspensions (Jackson, 1967).

3.5.1.2 Electrical conductivity

The soil water suspension used for measuring pH was kept overnight to get a clear solution. The electrical conductivity of the supernatant solution was measured with the help of conductivity bridge and expressed in dS m^{-1} (Jackson, 1967).

3.5.1.3 Organic carbon

Organic carbon content of soil samples was determined by Walkley and Blacks wet digestion method. The soil (0.5 mm sieved) was treated with chromic acid to oxidize organic carbon to CO_2 and untreated $K_2Cr_2O_7$ was back titrated against standard ferrous ammonium sulphate using diphenylamine indicator (Jackson, 1967). Organic carbon content in the soil was expressed as per cent.

3.5.1.4 Available nitrogen (kg ha^{-1})

The available nitrogen from soil was estimated by alkaline permanganate method (Subbiah and Asija, 1956). The easily oxidizable organic nitrogen present in soil was oxidized by potassium permanganate in the presence of NaOH by distillation. During oxidation, the released ammonia was absorbed in boric acid. To convert the ammonia to ammonium borate which was titrated with the standard sulphuric acid.

3.5.1.5 Available phosphorus (kg ha^{-1})

The Olsen's method was used for determining available phosphorus in soil in which phosphorus was extracted from the soil using 0.5 M sodium bicarbonate ($NaHCO_3$), pH 8.5 as an extractant. Phosphorus was estimated calorimetrically by adding ammonium molybdate to aliquot and reducing the molybdenum phosphate complex in acidic medium. The intensity of blue colour on reduction as a measure for concentration of phosphorus in extract was read on colorimeter using 730 nm red filters.

3.5.1.6 Available potassium (kg ha^{-1})

Available potassium was determined by extracting soil with neutral (1N) ammonium acetate (pH 7) solution and readings were recorded using Flame photometer (Jackson, 1967).

3.5.2 Grain and straw analysis

Plants used for dry matter study at harvest were utilized for estimation of nitrogen, phosphorous and potassium content. These plants were ground and N, P and K in straw and grain were estimated by the method suggested by Jackson (1967) as given below. The total nutrient uptake in kg ha^{-1} was calculated by using formula.

$$\text{Uptake by grain (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Seed yield (kg ha}^{-1}\text{)}}{100}$$

$$\text{Uptake by straw (kg ha}^{-1}\text{)} = \frac{\text{Nutrient content (\%)} \times \text{Straw yield (kg ha}^{-1}\text{)}}{100}$$

3.5.2.1 Total nitrogen (%)

Total nitrogen in plant samples was determined by Kjeldahl method in which complex nitrogenous compounds in plant samples were converted into ammonia and then to ammonium sulphate. The ammonia in the ammonium sulphate is released with NaOH during distillation and absorbed in a known volume of standard sulphuric acid. The unutilized excess of standard H_2SO_4 is determined by a back titration with standard sodium hydroxide. The total nitrogen is then calculated from amount of the standard H_2SO_4 neutralized by absorbed ammonia during distillation (Jackson, 1967).

3.5.2.2 Digestion of sample

For the nutrients other than nitrogen, the plant material was digested in a di-acid 9:4 HNO_3:$HClO_4$. The samples were pre digested with 25 ml HNO_3 $gram^{-1}$ sample to avoid explosion. Volume was made up with deionized water and the aliquots of this solution were used for the determination of P and K.

3.5.2.3 Phosphorus content

The phosphorus content in the plant sample was determined by vanadomolybdate yellow colour method in nitric acid medium. The intensity of colour was read at 420 nm wave length using spectrophotometer (Jackson, 1967).

3.5.2.4 Potassium content

Potassium content in the plant sample was estimated by atomizing the diluted plant extract in the Flame Photometer as described by Jackson (1967).

Nutrient uptake of nitrogen, phosphorous and potassium was calculated by multiplying the per cent N, P and K content with corresponding grain and straw yields of each treatment.

3.6 Quality studies

3.6.1 Protein content

Nitrogen content in seeds of Chickpea was estimated by Kjeldhal's method(Jackson, 1967). The protein per cent in seed was calculated by multiplying the nitrogen content by a factor of 6.25.

Crude protein (%) = % of N × 6.25

3.7.Biological properties of soil

3.7.1 Microbial analysis of soil

The rhizosphere soil collected were analyzed for viable population of bacteria, fungi and actinomycetes by the standard serial dilution plate count method using Media *viz:* Nutrient agar for bacteria , Potato dextrose agar for fungi . Actinomycetes Isolation agar and plates were incubated at 28±2^{0}C in an incubator in triplicates. The microbial colonies appearing after the stipulated time period of incubation were counted as Colony Forming Units (CFU) g^{-1} fresh weight of the sample in the colony counter. (Pahwa and Prakash, 1996)

3.8. Economics of the treatment

3.8.1 Cost of cultivation

The total cost of cultivation of chickpea ha^{-1} was calculated for treatment on the basis of inputs used.

3.8.2 Gross monetary returns (GMR)

The total values of produce i.e. seed yield and straw yield was estimated treatment wise as per prevailing market rate and treated as gross monetary returns. From this gross monetary returns ha^{-1} were calculated.

Gross monetary return (` $ha^{-1}$) = Cost of seed (` ha^{-1}) + Cost of straw (` ha^{-1})

3.8.3 Net monetary returns (NMR)

Net monetary returns were calculated by subtracting cost of cultivation from gross returns.

Net monetary return (` $ha^{-1}$) = Gross monetary return (` ha^{-1}) – Total cost of cultivation (` ha^{-1})

3.8.3 Benefit: Cost ratio

The benefit cost ratio is the ratio of gross returns to the cost of cultivation. It can also be expressed as returns per rupee invested. This was calculated with following formula.

$$\text{Benefit cost ratio} = \frac{\text{Gross monetary returns (` } ha^{-1}\text{)}}{\text{Cost of cultivation (` } ha^{-1}\text{)}}$$

3.9 Statistical analysis

The experimental data collected during the course of investigation were statistical analysed with randomized block design programmed on computer by adopting standard statistical techniques of analysis of variance (Gomez and Gomez,1984). Whenever, the results were significant, critical differences at P=0.05 level were calculated for comparison of treatment means. The data on interaction effects are presented whenever found significant. The data on treatment effects are presented suitably in appropriate tables and graphically depicted in figures.

CHAPTER IV

RESULTS AND DISCUSSION

The field experiment entitled "**Comparative study of conventional and biodynamic compost on performance of organic chickpea**" was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *rabi* season of 2017-18. The various growth, yield, nutrient uptake and economic aspects of the chickpea as influenced by application of compost have been studied in details and the results with the discussion are presented in this chapter under appropriate heads.

4.1.1 Initial plant count and final plant stand

Data pertaining to initial plant count and final plant stand as affected by various treatments are presented in Table 8. The initial plant count and final plant stand in net plot were 1068 and 1031 and per hectare were 4.23 lakh and 4.09 lakh respectively.

Table 8. Initial plant count and final plant stand of chickpea as influenced by various treatments

Treatment		Initial plant count		Final plant stand	
		Plant count net plot^{-1}	Plant count ha^{-1} (In lakh)	Plant stand net plot^{-1}	Plant stand ha^{-1} (In lakh)
T_1	Control	1062	421301	1025	406751
T_2	BD compost 5 t ha^{-1}	1064	422095	1028	407809
T_3	T_2 + soil conditioner 500	1072	425534	1037	411645
T_4	T_2+ soil conditioner 501	1070	424608	1026	407015
T_5	T_2 + soil conditioner 500 + 501	1073	425931	1038	412042
T_6	FYM 5 t ha^{-1}	1064	422227	1030	408603
T_7	Vermicompost 2.5 t ha^{-1}	1074	426063	1035	410851
S.E (m) ±		4.06	1613.61	3.27	1301.33
CD at 5%		NS	NS	NS	NS
GM		1068	423965	1031	409245

The data revealed that various treatment had no significant influenced on initial and final plant stand thereby indicating uniform emergence and persistence throughout the crop growth period, hence plant population was not variable factor.

Biometric observations

4.2.1 Plant height (cm)

Data in respect of plant height recorded at an interval of 20 days from sowing as influenced by different treatment are presented in Table 9 and graphically depicted in Fig. 4. The data indicated that mean height increased from 10.70 cm at 20 DAS to maximum 39.66 cm before harvest, it resulted that plant height was increased with advances in age of plant up to harvest stage of crop under all treatments. The rate of increasing plant height was maximum during 20 to 60 DAS thereafter plant height increased at decreasing rate compare to grand growth stage.

The plant height differed significantly influenced due to application of compost at all growth stages except at 20 DAS. At 40 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum plant height (26.18 cm) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (24.40). The treatment control (T_1) registered the lowest value of plant height (18.96 cm).

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum plant height (35.06 cm) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (33.87 cm). The treatment control (T_1) registered the lowest value of plant height (29.00 cm).

At 80 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum plant height (42.42 cm) which was at par with T2 + soil conditioner 500 + 501 (T_5) (39.60 cm). The treatment control (T_1) registered the lowest value of plant height (32.70 cm)

Table 9. Plant height (cm) of chickpea as influenced by various treatments

Treatment		Plant height (cm)				
		20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T_1	Control	10.11	18.96	29.00	32.70	34.58
T_2	BD compost 5 t ha^{-1}	10.40	21.63	30.62	35.98	37.19
T_3	T_2 + soil conditioner 500	10.71	21.27	31.28	36.76	38.35
T_4	T_2+ soil conditioner 501	10.77	23.23	32.23	37.53	40.02
T_5	T_2 + soil conditioner 500 + 501	11.01	24.40	33.87	39.60	42.14
T_6	FYM 5 t ha^{-1}	10.02	22.98	32.17	37.94	40.77
T_7	Vermicompost 2.5 t ha^{-1}	11.23	26.18	35.06	42.42	44.59
S.E (m) ±		0.44	0.79	0.86	0.93	1.06
CD at 5%		NS	2.45	2.67	2.88	3.29
GM		10.70	22.67	32.03	37.51	39.66

At harvest, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum plant height (44.59 cm) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (42.14 cm). The treatment control (T_1) registered the lowest value of plant height (34.58 cm).

These might be due to application of vermicompost accelerate proliferation of beneficial microbes and supply easily available NPK, micronutrients and also provide plant growth promoting hormone such as auxins, cytokinin and gibberellin secreted by earthworms. Similar finding has been reported earlier Singh *et al.* (2014) and Yadav *et.al*. (2017).

4.2.2 Number of branches plant^{-1}

The data regarding number of branches plant^{-1} as influenced by different treatment at different growth stages are presented in Table 10 and graphically depicted in Fig. 5. Mean number of branches plant^{-1} was increased from 2.75 to 15.30 up to 80 DAS.

Table 10. Number of branches plant^{-1} of chickpea as influenced by various treatments

Treatment		Number of branches plant^{-1}				
		20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T_1	Control	2.42	9.21	11.73	12.97	12.97
T_2	BD compost 5 t ha^{-1}	3.00	9.80	11.98	13.15	13.15
T_3	T_2 + soil conditioner 500	2.87	9.93	12.79	14.09	14.09
T_4	T_2+ soil conditioner 501	3.00	10.33	13.33	15.05	15.05
T_5	T_2 + soil conditioner 500 + 501	2.33	12.38	13.96	17.13	17.13
T_6	FYM 5 t ha^{-1}	2.60	10.13	12.85	14.76	14.76
T_7	Vermicompost 2.5 t ha^{-1}	3.03	13.29	16.50	19.98	19.98
S.E (m) ±		0.33	0.65	0.84	0.92	0.92
CD at 5%		NS	2.03	2.61	2.86	2.86
GM		2.75	10.72	13.31	15.30	15.30

The Number of branches plant^{-1} differed significantly influenced due to application of compost at all growth stages except at 20 DAS. At 40 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum number of branches (13.29) which was at par with BD compost 5 t ha^{-1}+ soil conditioner 500 + 501 (T_5) (12.38). The treatment Control (T_1) registered the lowest value of number of branches (9.21).

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum number of branches (16.50) which was at par with T2 + soil conditioner 500 + 501 (T_5) (13.96). The treatment control (T_1) registered the lowest value of number of branches (11.73).

At 80 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum branches (19.98) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (17.13). The treatment control (T_1) registered the lowest value of number of branches (12.97).

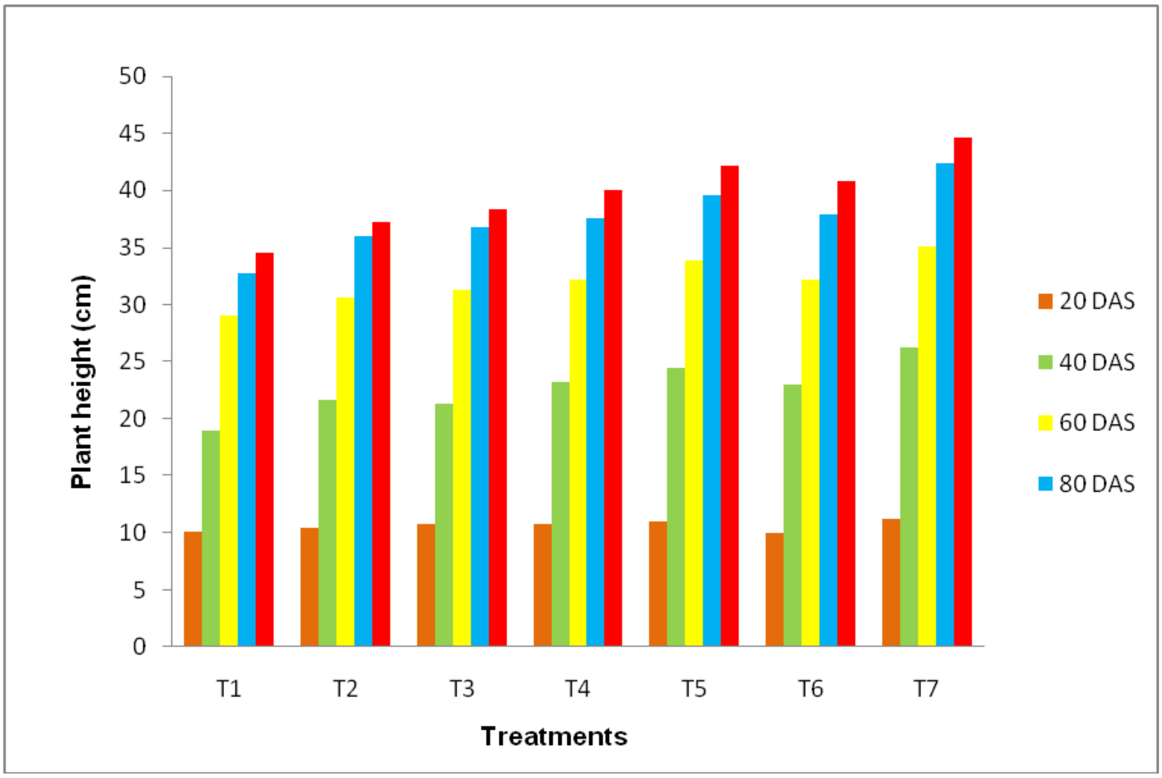

Fig. 4: Plant height (cm) of chickpea as influenced by various treatments

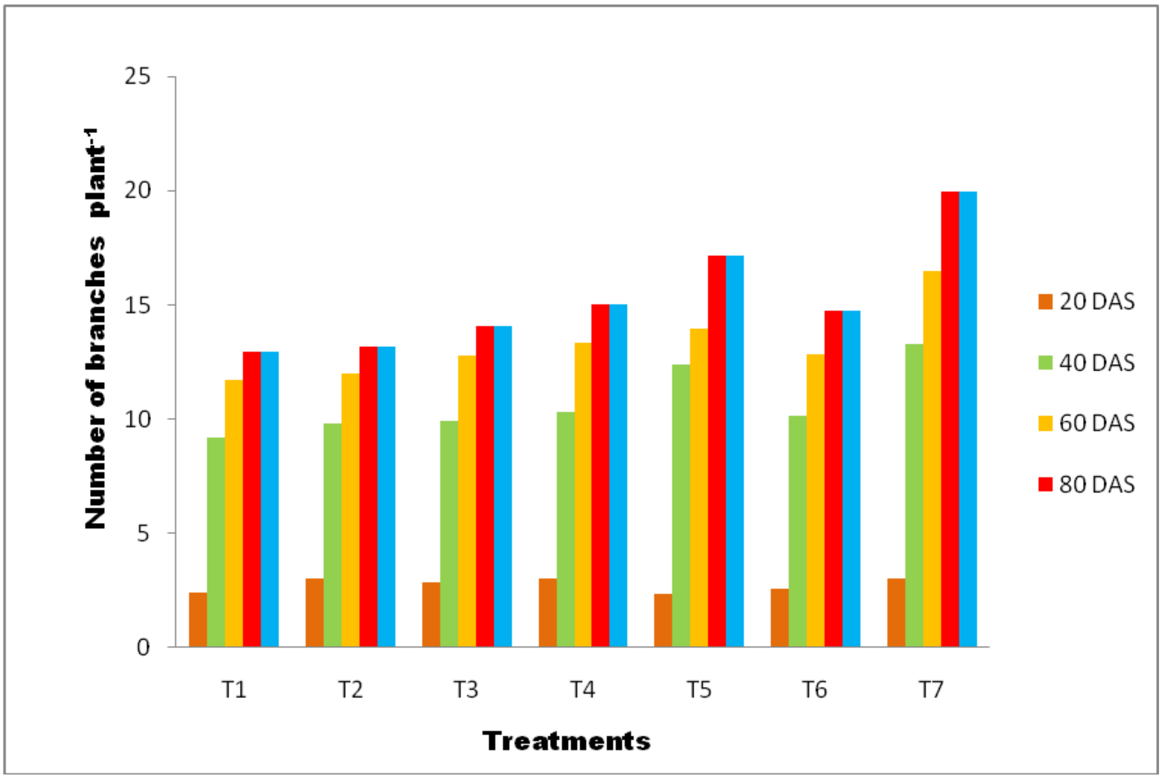

Fig. 5: Number of branches plant^{-1} of chickpea as influenced by various treatments

Increase in number of branches plant^{-1} might be due to increase in rate of metabolic processes by plant due to presence humic acid, gibberellin and cytokinin. Similar finding has been reported earlier Singh *et al.* (2014) and Yadav *et.al*. (2017).

4.2.3. Number of leaves plant^{-1}

The number of leaves plant^{-1} as influenced by different treatments are presented in Table 11 and graphically illustrated in Fig.6. The average number of functional leaves plant^{-1} increased progressively from 20 to 60 DAS thereafter the rate of production of number of leaves formation was slow as compare to grand growth stage. It may be due dropping of older leaves by process of senescence.

Effect of application of compost on number of leaves plant^{-1} was significantly influenced at all the growth stages except at 20 DAS.

At 40 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum number of leaves plant^{-1} (100.87) which was at par with T_2 + soil conditioner 500 +501 (T_5) (91.67) and treatment control (T_1) registered the lowest value of number of leaves plant^{-1} (70.79)

Table 11. Number of leaves plant^{-1} of chickpea as influenced by various treatments

Treatment		Number of leaves plant^{-1}			
		20 DAS	40 DAS	60 DAS	80 DAS
T_1	Control	19.33	70.79	168.67	122.00
T_2	BD compost 5 t ha^{-1}	22.33	77.20	196.67	136.33
T_3	T_2 + soil conditioner 500	20.33	74.51	166.33	135.51
T_4	T_2+ soil conditioner 501	21.33	76.33	183.33	146.40
T_5	T_2 + soil conditioner 500 + 501	18.27	91.67	202.67	165.00
T_6	FYM 5 t ha^{-1}	15.78	71.43	177.67	152.12
T_7	Vermicompost 2.5 t ha^{-1}	21.60	100.87	212.00	178.20
S.E (m) ±		1.65	4.20	5.86	7.02
CD at 5%		NS	12.95	18.06	21.65
GM		19.85	80.40	186.76	147.76

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum number of leaves $plant^{-1}$ (212) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (202.67). The treatment control (T_1) registered the lowest value of number of leaves $plant^{-1}$ (168.67).

At 80 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum number of leaves $plant^{-1}$ (178.20) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (165.00). The treatment control (T_1) registered the lowest value of number of leaves $plant^{-1}$(122.00).

Increase in number of leaves $plant^{-1}$ might be due to the availability of higher quantity of nutrients, improvement in the physical properties of soil and increased activity of microbes with application of vermicompost. These results were supporting the findings of Borey (2013) and Degwale (2017).

4.2.4. Leaf area $plant^{-1}$ (dm^2)

The data regarding to leaf area $plant^{-1}$ as influenced by different treatments are presented in Table 12 and graphically depicted in Fig. 7.

Leaf area $plant^{-1}$ of chickpea increases steadily with advance in the age of the crop up to 60 DAS and then found declined towards harvest due to senescence of lower leaves.

The Leaf area $plant^{-1}$ differed significantly due to application of compost at all growth stages except at 20 DAS.

At 40 DAS, the application of the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum leaf area $plant^{-1}$ (12.96 dm^2) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (11.17 dm^2). The treatment control (T_1) registered the lowest value of Leaf area $plant^{-1}$ (8.53).

The leaf area recorded at 60 DAS was found to be maximum with application of vermicompost 2.5 t ha^{-1} (T_7) (17.41 dm^2) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (15.00 dm^2). The treatment control (T_1) registered the lowest value of Leaf area $plant^{-1}$ (11.52 dm^2).

Table 12. Leaf area (dm^2) $plant^{-1}$ as influenced by various treatments in chickpea

Treatment		Leaf area $plant^{-1}$ (dm^2)			
		20 DAS	**40 DAS**	**60 DAS**	**80 DAS**
T_1	Control	1.80	8.53	11.52	8.53
T_2	BD compost 5 t ha^{-1}	2.07	9.09	11.85	10.15
T_3	T_2 + soil conditioner 500	2.16	9.13	13.79	10.30
T_4	T_2+ soil conditioner 501	2.51	9.53	14.38	10.80
T_5	T_2 + soil conditioner 500 + 501	2.62	11.17	15.00	11.67
T_6	FYM 5 t ha^{-1}	2.30	10.37	12.32	10.45
T_7	Vermicompost 2.5 t ha^{-1}	2.69	12.96	17.41	13.94
S.E (m) ±		0.25	0.52	0.57	0.42
CD at 5%		NS	1.62	1.78	1.30
GM		2.31	10.11	13.75	10.83

At 80 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum leaf area $plant^{-1}$ (13.94 dm^2) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (11.67 dm^2). However, the lowest value of leaf area $plant^{-1}$ (8.53 dm^2) observed in control (T_1).

This increased in leaf area was due to application of vermicopmpost increases number of functional leaves and large quantity of nutrient supply through organic sources to crop resulted increased cell division and thereby increase in leaf area $plant^{-1}$. Similar result was reported by Borey (2013) and Degwale (2017).

4.2.5 Dry matter accumulation $plant^{-1}$ (g)

The data on total dry matter accumulation of plants as influenced by different treatments recorded periodically are presented in Table 13 and illustrated in Fig. 8.

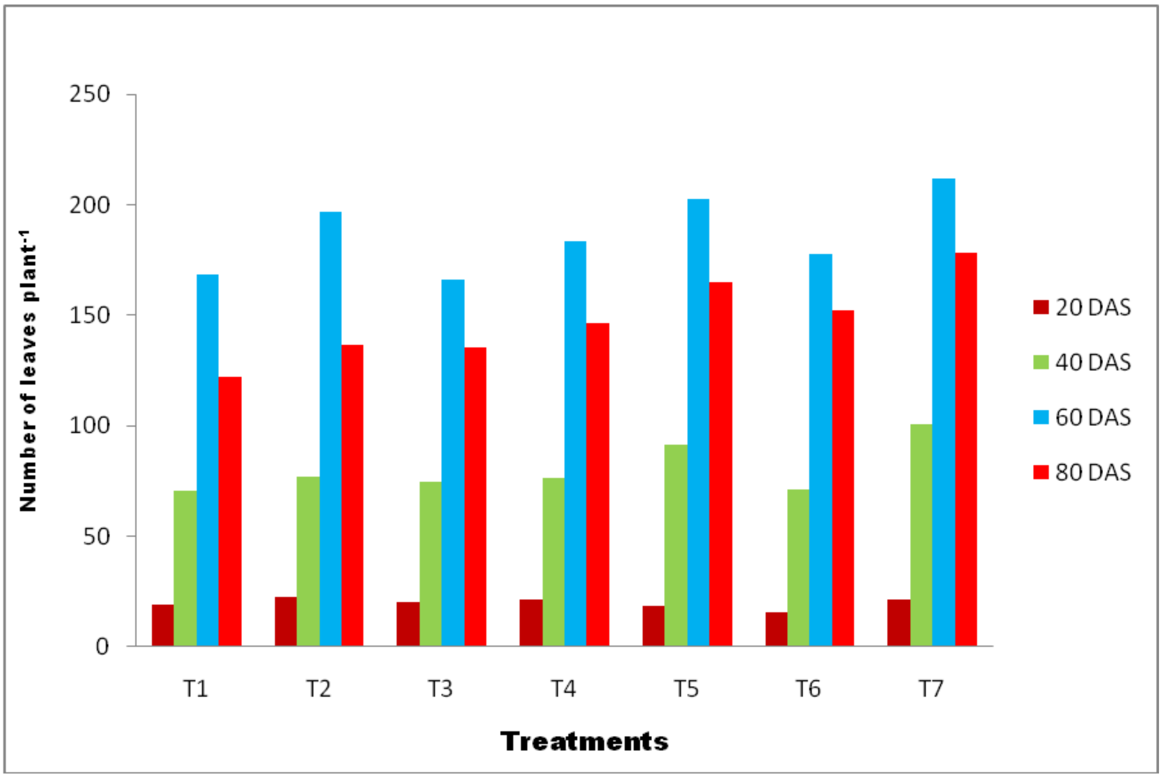

Fig. 6: Number of leaves plant^{-1}of chickpea as influenced by various treatments

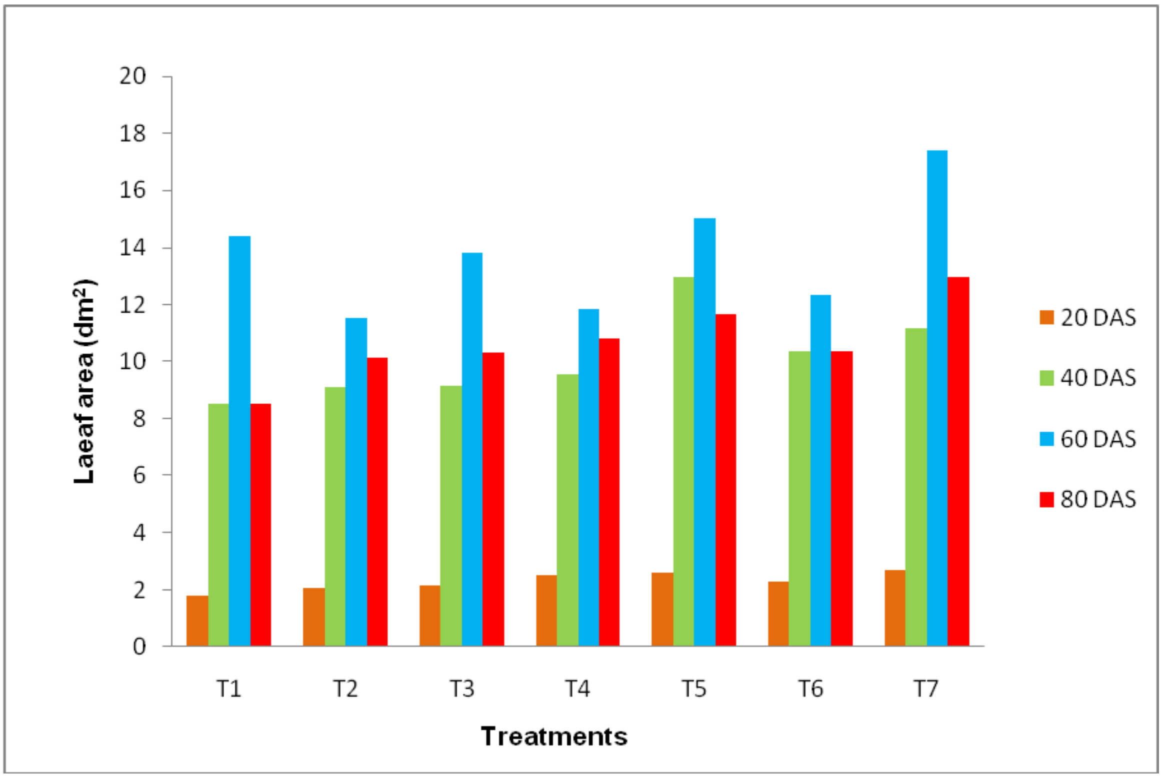

Fig. 7: Leaf area (dm^2) plant^{-1} of chickpea as influenced by various treatments

Table 13. Dry matter accumulation (g) $plant^{-1}$ of chickpea as influenced by various treatments

Treatment		Dry matter accumulation $plant^{-1}$ (g)				
		20 DAS	40 DAS	60 DAS	80 DAS	At harvest
T_1	Control	0.22	1.14	9.59	13.52	15.24
T_2	BD compost 5 t ha^{-1}	0.27	1.78	10.68	15.98	17.42
T_3	T_2 + soil conditioner 500	0.27	1.97	10.71	16.23	18.47
T_4	T_2+ soil conditioner 501	0.29	2.24	11.24	17.58	19.75
T_5	T_2 + soil conditioner 500 + 501	0.27	2.42	14.80	17.93	20.40
T_6	FYM 5 t ha^{-1}	0.30	2.16	10.79	16.39	18.48
T_7	Vermicompost 2.5 t ha^{-1}	0.31	2.70	16.07	20.47	23.22
S.E (m)±		0.33	0.14	0.63	0.83	1.01
CD at 5%		NS	0.45	1.95	2.58	3.11
GM		0.28	2.06	11.98	16.87	19.00

At 20 DAS, the dry matter accumulation $plant^{-1}$ was not significantly influenced due to treatment differences

Whereas 40 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum dry matter accumulation $plant^{-1}$ (2.70 g) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (2.42 g). The treatment control (T_1) registered the lowest value of dry matter accumulation $plant^{-1}$ (1.14 g).

The dry matter accumulation $plant^{-1}$ at 60 DAS was found to be maximum with application of vermicompost 2.5 t ha^{-1} (T_7) (16.07 g) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (14.80 g). However, the lowest value of dry matter accumulation $plant^{-1}$ (9.59 g) was recorded with control (T_1).

The dry matter accumulation plant^{-1} recorded at 80 DAS was found to be maximum with application of vermicompost 2.5 t ha^{-1} (T_7) (20.47 g) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (17.93 g). The treatment control (T_1) registered the lowest value of dry matter accumulation plant^{-1} (13.52 g).

At harvest, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum dry matter accumulation plant^{-1} (23.22 g) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (20.40 g). However, the lowest value of dry accumulation plant^{-1} (15.24 g) was observed in control (T_1).

Dry matter accumulation is the prerequisite for higher yields, which is an indication of the biosynthetic process associated with the crop growth and development. Total dry matter accumulation was significantly influenced mainly due to greater availability of nutrients in soil, improved soil environment and higher root penetration leading to better absorption of moisture and nutrient which improves photosynthesis and translocation assimilates. These results were supporting the findings Jat and Ahlawat (2006), Singh *et. al.* (2014) and Yadav *et.al*. (2017).

4.2.6 Canopy spread plant^{-1}

The data regarding the canopy spread plant^{-1} as influenced by application of compost were recorded and presented in Table 14 and Fig. 9.

In early stage of chickpea crop spread plant^{-1} was not significantly influenced due to treatment differences. Whereas at 60 DAS and 90 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum canopy spread plant^{-1} in N-S and E-W direction which was at par with T_2 + soil conditioner 500 + 501 (T_5). The treatment control (T_1) registered the lowest value of canopy spread plant^{-1}.

Table14. Canopy spread (cm) plant^{-1} of chickpea as influenced by various treatments

Treatment		Canopy spread plant^{-1} (cm)					
		30 DAS		60 DAS		90 DAS	
		N-S	E-W	N-S	E-W	N-S	E-W
T_1	Control	18.32	11.30	31.33	21.07	37.40	25.73
T_2	BD compost 5 t ha^{-1}	18.69	12.63	31.93	24.03	38.63	28.03
T_3	T_2 + soil conditioner 500	20.01	12.60	31.90	24.80	39.93	28.80
T_4	T_2+ soil conditioner 501	21.62	10.95	33.17	25.47	41.40	28.70
T_5	T_2 + soil conditioner 500 + 501	21.92	14.33	38.03	29.33	44.90	32.33
T_6	FYM 5 t ha^{-1}	20.61	10.57	34.13	24.70	40.83	29.47
T_7	Vermicompost 2.5 t ha^{-1}	21.58	13.33	38.87	33.17	46.23	35.17
S.E (m)±		1.1	1.04	1.11	2.09	1.25	1.69
CD at 5%		NS	NS	3.43	6.46	3.86	5.21
GM		20.29	12.25	34.20	25.51	41.33	29.75

4.2.6 Days to 50% flowering

The data regarding the days to flowering as influenced by application of compost are recorded and presented in Table 15.

Table 15. Days to 50% flowering of chickpea as influenced by various treatments

Treatments		Days to 50% flowering
T_1	Control	48
T_2	BD compost 5 t ha^{-1}	50
T_3	T_2 + soil conditioner 500	52
T_4	T_2+ soil conditioner 501	51
T_5	T_2 + soil conditioner 500 + 501	51
T_6	FYM 5 t ha^{-1}	50
T_7	Vermicompost 2.5 t ha^{-1}	52
SE (m)±		1.09
CD at 5%		NS
GM		50

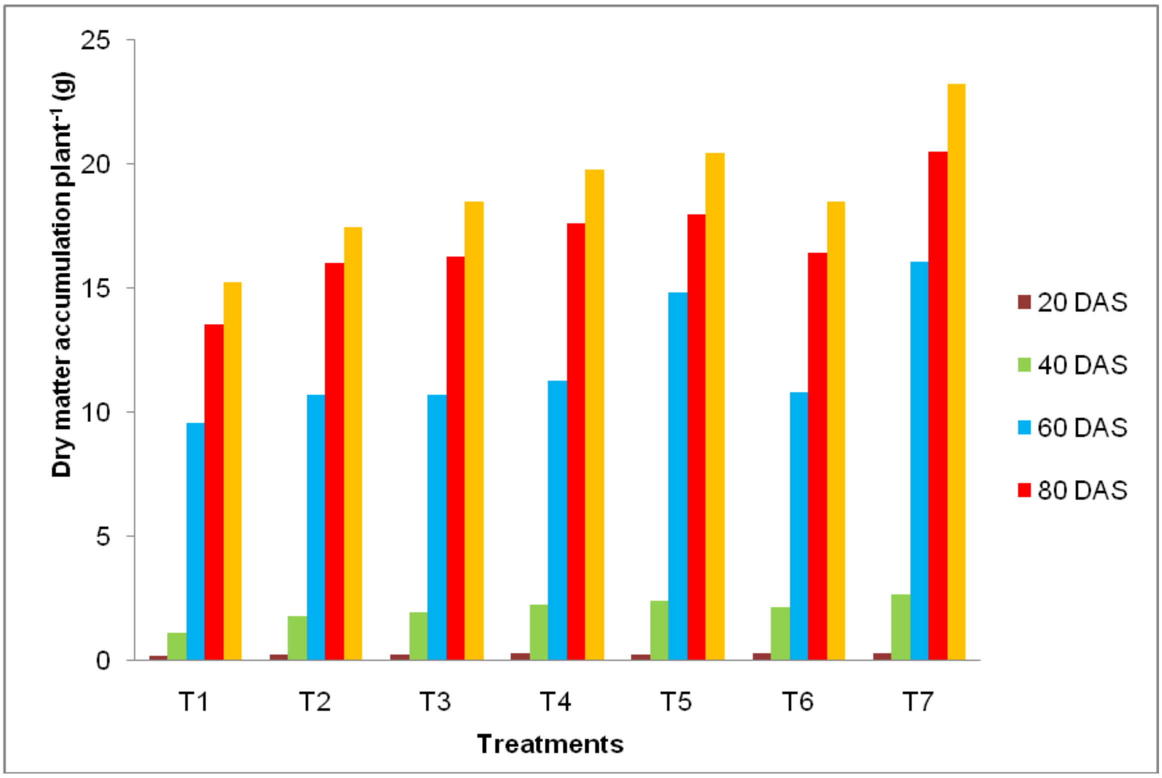

Fig. 8: Dry matter accumulation (g) plant^{-1} of chickpea as influenced by various treatments

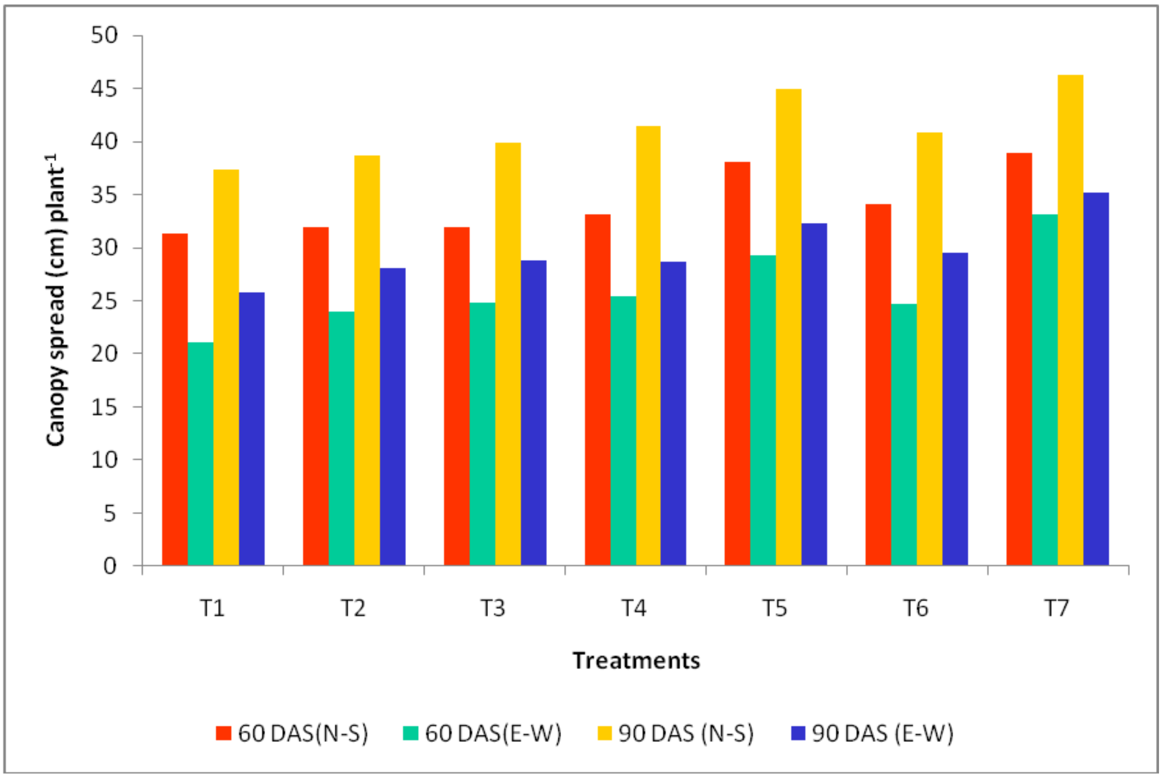

Fig. 9. Canopy spread (cm) plant^{-1} of chickpea as influenced by various treatments

The days to 50% flowering of chickpea did not reach to the level of significance due to treatment differences. The mean of days to 50% flowering was 50 days in chickpea crop was reached during investigation.

4.3. Root studies

4.3.1 Number of root nodules plant^{-1}

The data regarding the number of root nodules plant^{-1} as influenced by different treatments are presented in Table 16 and graphically depicted in Fig.10. The maximum number of root nodules plant^{-1} was found at 60 DAS.

The data presented in table indicated that the functional root nodules plant^{-1} was increased from 30 DAS to 90 DAS. The maximum functional root nodule was recorded at 60 DAS.

Table 16. Root nodules plant^{-1} of chick pea influenced by different treatments

Treatment		Root nodules plant^{-1}		
		30 DAS	**60 DAS**	**90 DAS**
T_1	Control	16	27	18
T_2	BD compost 5 t ha^{-1}	16	30	22
T_3	T_2 + soil conditioner 500	17	28	22
T_4	T_2+ soil conditioner 501	17	31	23
T_5	T_2 + soil conditioner 500 + 501	18	36	26
T_6	FYM 5 t ha^{-1}	16	29	23
T_7	Vermicompost 2.5 t ha^{-1}	20	39	27
S.E (m)±		1.05	1.14	0.79
CD at 5%		NS	3.52	2.44
GM		17	32	23

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum root nodule plant^{-1} (39) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (36) treatment. The treatment control (T_1) registered the lowest value of root nodule plant^{-1} (27).

At 90 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum root nodule $plant^{-1}$ (27) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (23). The treatment control (T_1) registered the lowest value of root nodule $plant^{-1}$ (18).

Different types of enzymes produced in vermicompost that help to produce more number of nodules in $plant^{-1}$. Similar observation was recorded by Yadav *et.al*. (2017).

4.3.2 Root length $plant^{-1}$

Data regarding root length $plant^{-1}$ presented in Table 17 and graphically depicted in Fig. 11.

Table 17. Root length (cm) $plant^{-1}$ of chickpea as influenced by various treatments

Treatment		Root length $plant^{-1}$ (cm)		
		30 DAS	60 DAS	90 DAS
T_1	Control	8.53	14.97	15.53
T_2	BD compost 5 t ha^{-1}	11.60	16.33	18.40
T_3	T_2 + soil conditioner 500	11.93	17.23	19.23
T_4	T_2+ soil conditioner 501	11.10	16.03	19.77
T_5	T_2 + soil conditioner 500 + 501	12.20	18.27	21.23
T_6	FYM 5 t ha^{-1}	10.87	16.37	18.27
T_7	Vermicompost 2.5 t ha^{-1}	12.87	20.91	22.71
S.E (m) ±		0.892	0.73	0.82
CD at 5 %		NS	2.27	2.54
GM		11.30	17.46	19.31

The data clearly indicated that, the root length $plant^{-1}$ was not significantly influenced due to application of compost treatment from 60 and 90 DAS except 30 DAS.

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum root length $plant^{-1}$ (20.91 cm) which was at par with T_2

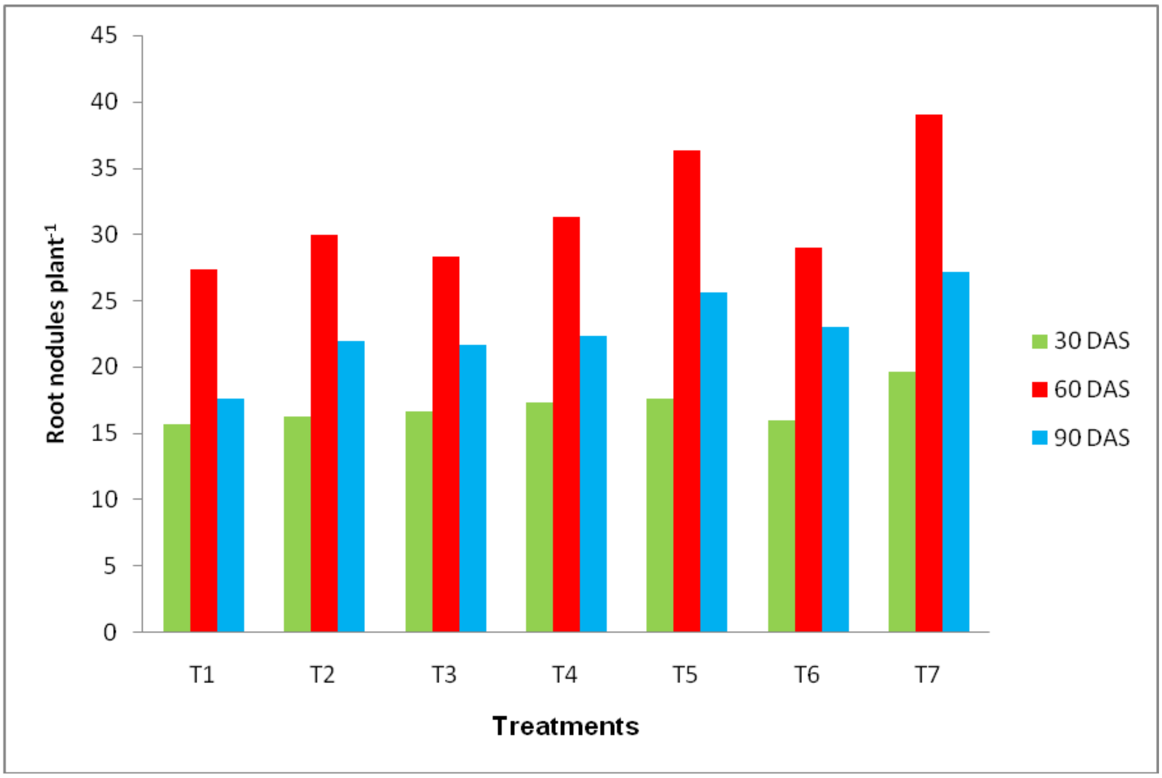

Fig. 10: Root nodules plant^{-1} of chickpea as influenced by various treatments

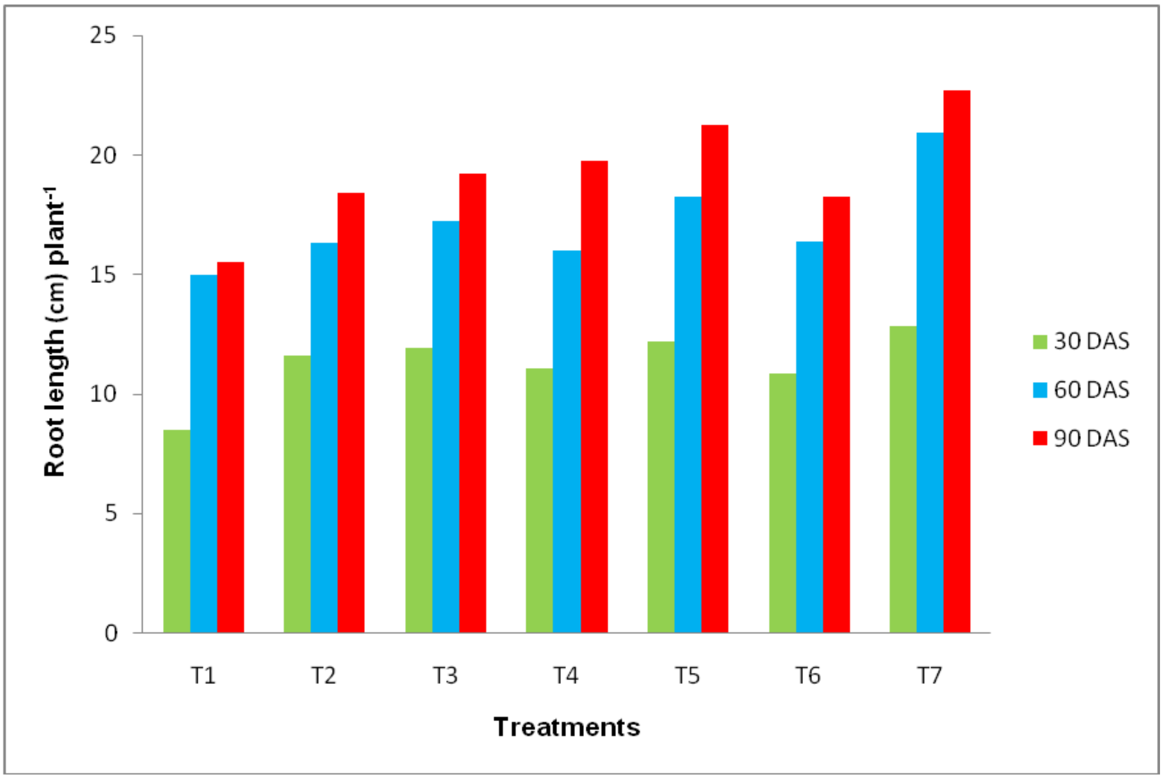

Fig. 11: Root length (cm) plant^{-1}of chickpea as influenced by varioustreatments

+ soil conditioner 500 + 501 (T_5) (18.27 cm). The treatment control (T_1) registered the lowest value of maximum root length plant^{-1} (14.97 cm).

At 90 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum root length plant^{-1} (22.71 cm) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (21.23 cm). The treatment control (T_1) registered the lowest value of root length plant^{-1} (15.53 cm).

The root length increases might be due to improvement in physical properties and presence of indole acetic acid in vermicompost.

4.3.3 Root weight plant^{-1}

The data pertaining to root weight per plant as influenced by different treatments are presented in Table 18 and graphically depicted in Fig. 12.

Table 18. Root weight (g) plant^{-1} of chickpea as influenced by various treatments

Treatment		Root weight plant^{-1} (g)		
		30 DAS	60 DAS	90 DAS
T_1	Control	0.27	0.62	0.80
T_2	BD compost 5 t ha^{-1}	0.30	0.67	0.82
T_3	T_2 + soil conditioner 500	0.32	0.70	0.85
T_4	T_2+ soil conditioner 501	0.35	0.71	0.89
T_5	T_2 + soil conditioner 500 + 501	0.39	0.88	0.92
T_6	FYM 5 t ha^{-1}	0.33	0.69	0.72
T_7	Vermicompost 2.5 t ha^{-1}	0.37	0.94	1.09
S.E (m) ±		0.039	0.05	0.06
CD at 5 %		NS	0.18	0.21
GM		0.33	0.74	0.87

The data clearly indicated that, the root weight plant^{-1} was significantly influenced due to application of compost treatment at 60 and 90 DAS except 30 DAS.

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum the root weight $plant^{-1}$ (0.94 g) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (0.88 g). The treatment control (T_1) registered the lowest value of root weight $plant^{-1}$ (0.62 g).

At 90 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum canopy spread $plant^{-1}$ (1.09 g) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (0.92 g). The treatment control (T_1) registered the lowest value of root weight $plant^{-1}$ (0.80 g).

Increasing root weight $plant^{-1}$ may be due to increasing root length and improvement in soil properties. Singh *et*. *al.* 2014 recorded the similar type of results.

4.3.4 Root volume $plant^{-1}$

The data regarding the root volume $plant^{-1}$ as influenced by application of compost were recorded and presented in Table 19 and graphically depicted in Fig.13.

Table 19. Root volume (cm^3) $plant^{-1}$ of chickpea as influenced by various treatments

Treatment		Root volume $plant^{-1}$ (cm^3)		
		30 DAS	60 DAS	90 DAS
T_1	Control	1.20	2.17	2.73
T_2	BD compost 5 t ha^{-1}	1.63	2.50	3.27
T_3	T_2 + soil conditioner 500	1.50	2.45	3.23
T_4	T_2+ soil conditioner 501	1.60	2.50	3.37
T_5	T_2 + soil conditioner 500 + 501	1.63	2.90	3.63
T_6	FYM 5 t ha^{-1}	1.53	2.23	3.13
T_7	Vermicompost 2.5 t ha^{-1}	1.70	2.93	3.96
S.E (m) ±		0.15	0.15	0.20
CD at 5 %		NS	0.49	0.63
GM		1.54	2.5	3.33

The root volume $plant^{-1}$ was not significantly influenced due to application of compost treatment at 60 and 90 DAS except 30 DAS.

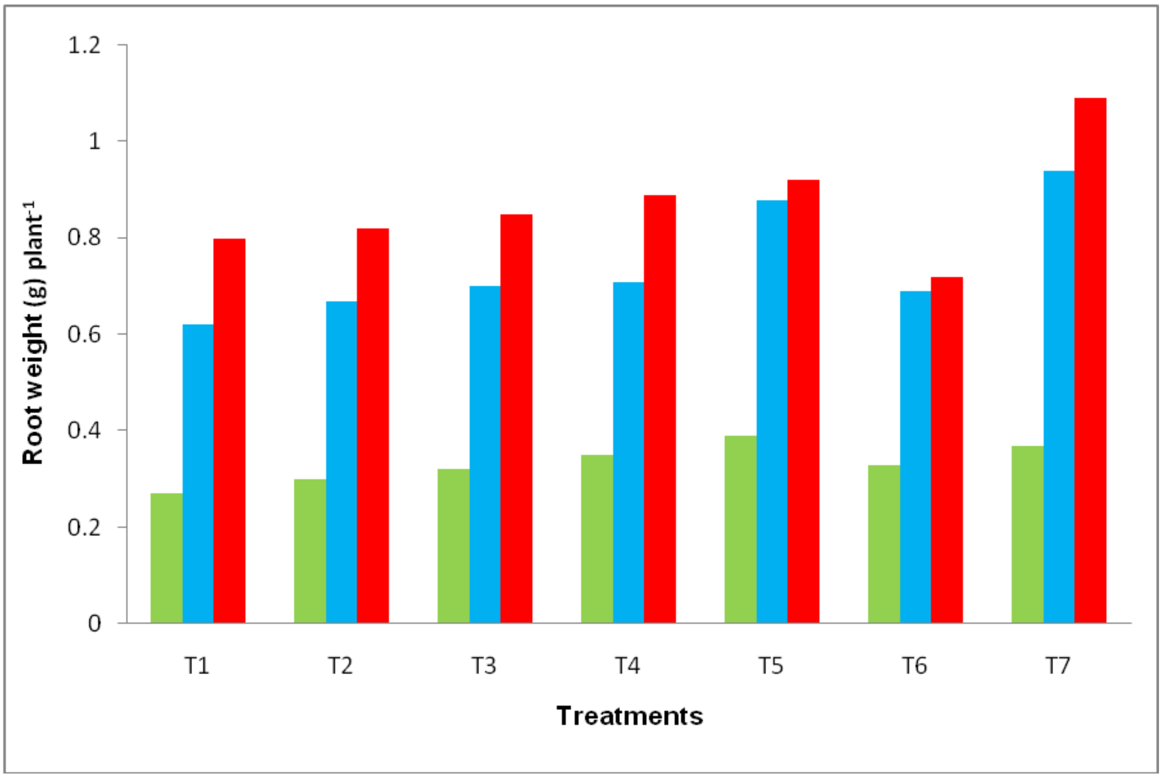

Fig. 12: Root weight (g) plant^{-1} of chickpea as influenced by varioustreatments

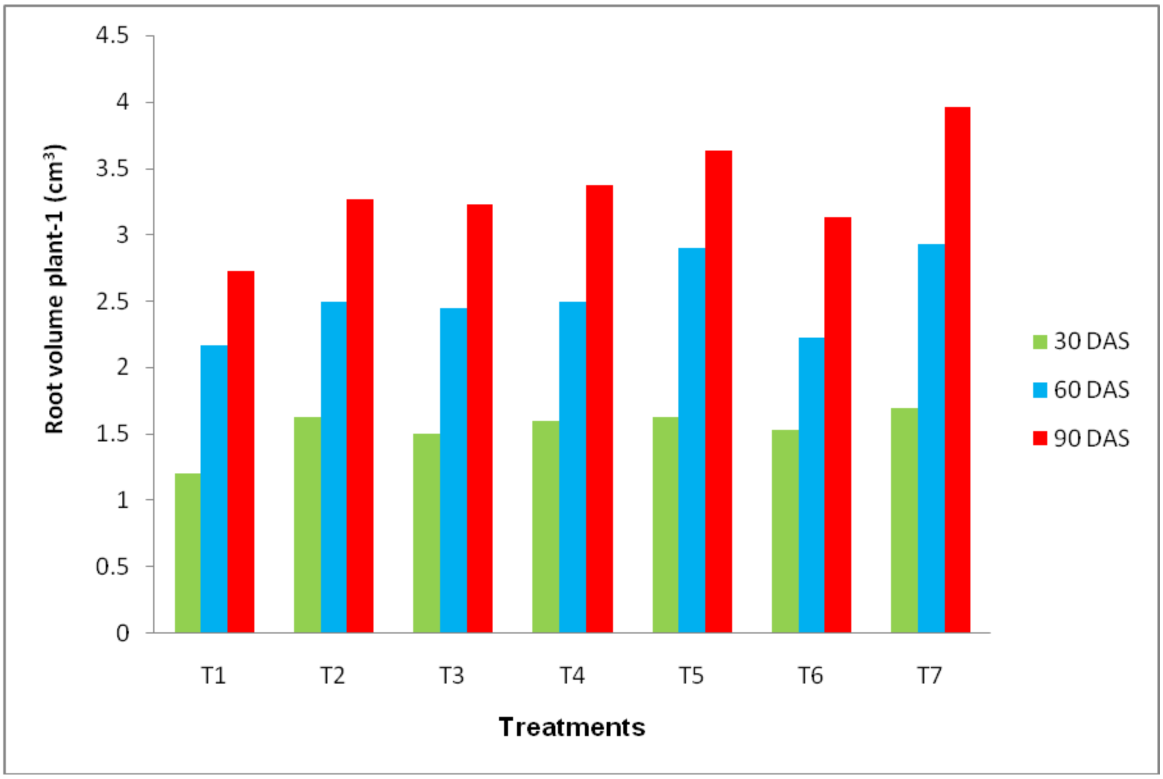

Fig. 13: Root volume plant^{-1}(cm^3) of chickpea as influenced by various treatments

At 60 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum the root volume $plant^{-1}$ (2.93 cm^3) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (2.90 cm^3). The treatment control (T_1) registered the lowest value of root volume $plant^{-1}$ (2.17 cm^3).

At 90 DAS, the application of vermicompost 2.5 t ha^{-1} (T_7) recorded maximum root volume $plant^{-1}$ (3.96 cm^3) which was at par with BD compost 5 t ha^{-1}+ soil conditioner 500 + 501 (T_5) (3.63 cm^3). The treatment control (T_1) registered the lowest value of root volume $plant^{-1}$ (2.73 cm^3).

These might be due to increasing root length and root weight directly influenced on root volume of chickpea.

4.4 Post harvest observation

4.4.1 Yield attributes

Data on yield attributes *viz*., number of pods $plant^{-1}$, pod weight $plant^{-1}$, grain weight $plant^{-1}$ and 100 seed weight as influenced by various treatments are presented in Table 20 and depicted in Fig.14.

Table 20. Yield attributes of chickpea as influenced by various treatments

Treatment		Number of pod $plant^{-1}$	Pod weight $plant^{-1}$ (g)	Seed weight $plant^{-1}$ (g)	100 seed weight (g)
T_1	Control	23.19	8.33	6.27	23.93
T_2	BD compost 5 t ha^{-1}	28.81	10.63	9.60	24.33
T_3	T_2 + soil conditioner 500	29.41	12.03	9.73	24.17
T_4	T_2+ soil conditioner 501	31.07	12.33	10.37	24.97
T_5	T_2 + soil conditioner 500 + 501	33.07	14.47	11.43	25.17
T_6	FYM 5 t ha^{-1}	29.47	12.13	9.60	24.83
T_7	Vermicompost 2.5 t ha^{-1}	34.95	14.90	12.10	26.00
S.E (m) ±		1.46	0.90	0.94	0.72
CD at 5 %		4.52	2.79	2.90	NS
GM		29.99	12.12	9.87	24.77

Mean values of number of pods plant^{-1}, pod weight plant^{-1}, seed weight plant^{-1} and 100 seed weight were 29.99, 12.12 g, 9.87 g and 24.77 g respectively.

4.4.1 Number of pods plant^{-1}

The number of pod plant^{-1} is one of the most important reproductive characters which influenced seed yield of chickpea.

The treatment, vermicompost 2.5 t ha^{-1} recorded highest number of pod plant^{-1} (34.95) which was at par with T_2 + soil conditioner 500 + 501 (T_5) (33.07). The lowest number of pod plant^{-1} was recorded with control (23.19)

Significant increased in number of pod plant^{-1} with vermicompost application might be due to significant increased in growth parameter like plant height; number of branches, functional leaves and dry matter accumulation and better translocation of assimilates towards sink with optimum dose of vermicompost. The present results are in accordance with the findings of Singh *et. al.* (2014) and Yadav *et.al.* (2017).

4.4.2 Pod weight plant^{-1} (g)

The data pertaining to weight of pods plant^{-1} are given in Table 20 and depicted in Fig. 14.

It was observed that pod weight plant^{-1} was significantly influenced due to application of compost. The maximum pod weight plant^{-1} (14.90 g) was recorded by the treatment vermicompost 2.5 t ha^{-1} (T_7) and it was found at par with $T_{2\,+}$ soil conditioner 500+ 501 (14.47 g). Control treatment (T_1) registered the lowest mean value of pod weight plant^{-1} (8.33).

4.4.3 Seed weight plant^{-1}(g)

The data presented in Table 20 and graphically depicted in fig 14 indicated that seed weight plant^{-1} was significantly influenced due to treatment differences.

The maximum seed weight plant^{-1} was recorded by the treatment Vermicompost 2.5 t ha^{-1} (T_7) (12.10 g) which was at par T_2 + Soil conditioner 500 + 501 (T_5) (11.43 g). The control treatment (T_1) registered the lowest mean value of seed weight plant^{-1} (6.27 g).

4.4.4 100- seed weight (g)

The data pertaining to 100 seed weight was given in Table 20. It was observed that, 100 seed weight not significantly influenced due to various treatments. However, the treatment T_7 (vermicompost) recorded numerically higher value of 100 seed weight (g) as compared to rest of treatment. The mean value of 100 seed weight was 24.77 g.

4.4.5 Yield studies

The data on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}) and harvest index (%) as influenced by various treatments are presented in Table 21 and graphically illustrated in Fig. 15.

Table 21. Seed yield, straw yield, biological yield and harvest index of chickpea as influenced by various treatments

Treatment		Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1	Control	1115	1633	2748	40.57
T_2	BD compost 5 t ha^{-1}	1488	2135	3623	40.98
T_3	T_2 + soil conditioner 500	1513	2215	3728	40.60
T_4	T_2+ soil conditioner 501	1581	2343	3924	40.32
T_5	T_2 + soil conditioner 500 + 501	1705	2443	4148	40.96
T_6	FYM 5 t ha^{-1}	1534	2088	3622	42.50
T_7	Vermicompost 2.5 t ha^{-1}	1840	2365	4205	43.75
S.E (m) ±		94	107	153	-
CD at 5 %		289	332	473	-
GM		1539	2174	3714	41.38

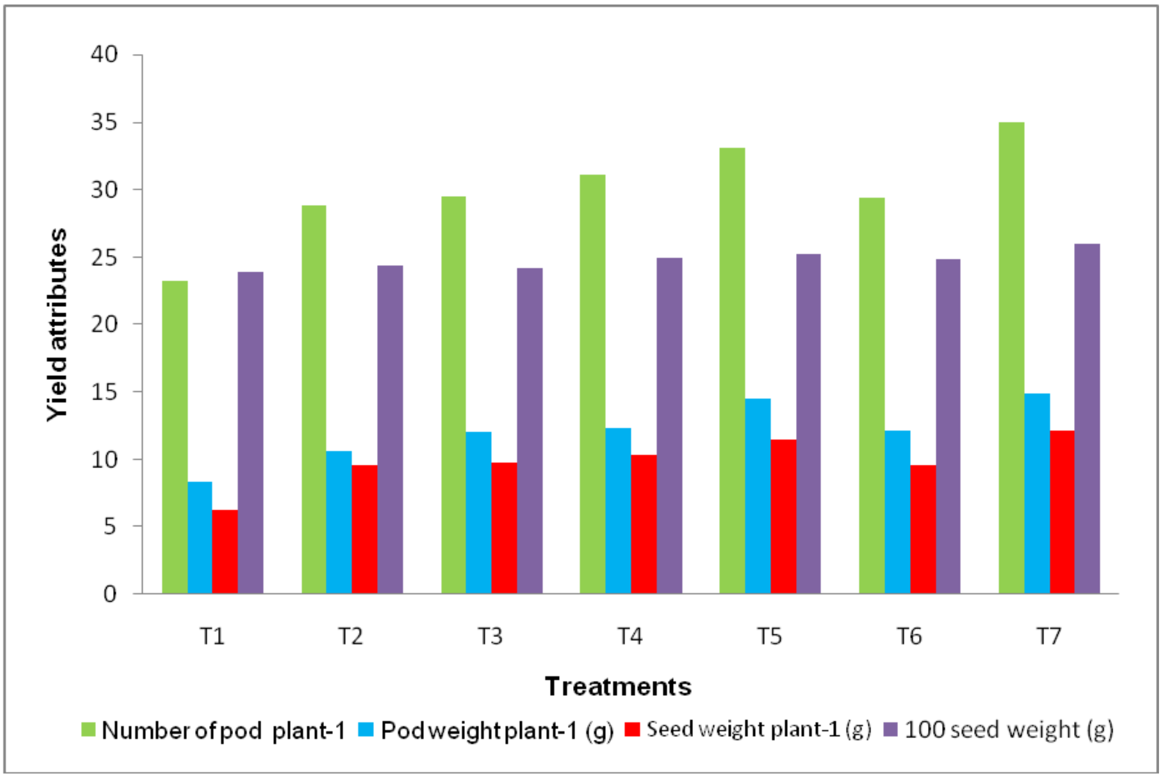

Fig. 14: Yield attributes of chickpea as influenced by various treatments

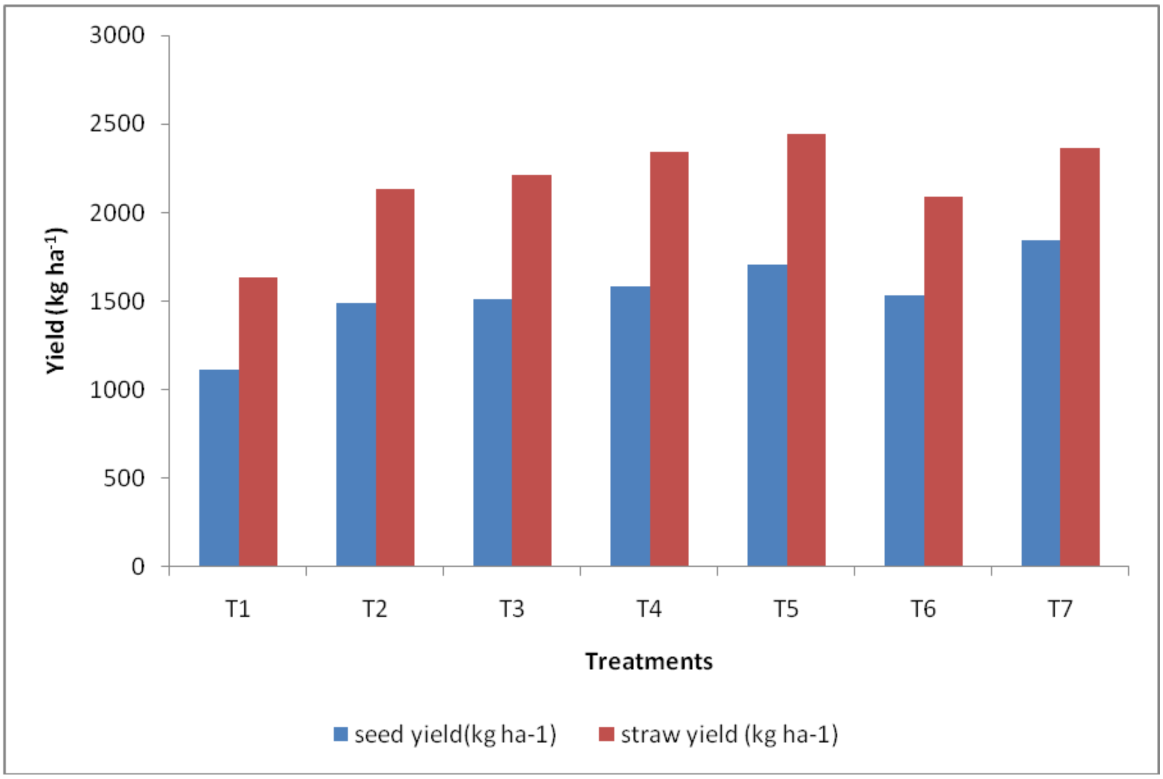

Fig 15. Seed yield and straw yield of chickpea as influenced by various treatments

4.4.5 Seed yield (kg ha^{-1})

Grain yield of chickpea was significantly influenced by application of compost treatments. Mean seed yield per hectare was 1539 kg ha^{-1}.

Maximum seed yield was recorded with application of vermicompost 2.5 t ha^{-1} (T_7) (1840 kg ha^{-1}) which was at par with T_2 + Soil conditioner 500 + 501 (T_5) (1705 kg ha^{-1}). The lowest seed yield (1115 kg ha^{-1}) was recorded in control (T_1) treatment.

These might be due to marked improvement in dry matter accumulation, yield attributes and greater nutrients content and their uptake by chickpea. These finding closely accordance with Singh *et*. *al.* (2014), Yadav *et.al*. (2017).

4.4.6 Straw yield (kg ha^{-1})

Straw yield chickpea was significantly influenced by application of compost treatments. Mean straw yield per hectare was 2174 kg ha^{-1}.

The maximum straw yield was recorded with application of vermicompost 2.5 t ha^{-1} (2365 kg ha^{-1}) (T_7) which at par with T_2+ Soil conditioner 500 + 501 (T_5) (2443 kg ha^{-1}). The control recorded minimum straw yield (T_1) (1633 kg ha^{-1}). Similar result was reported by Singh *et*. *al.* (2014), Yadav *et.al*. (2017)

4.4.7 Biological yield (kg ha^{-1})

Biological yield plant^{-1} differed significantly due to the application of compost. Maximum biological yield recorded in vermicompost 2.5 t ha^{-1} (4205 kg ha^{-1}) (T_7) which at par with T_2 + Soil conditioner 500 + 501 (T_5) (4148 kg ha^{-1}). The control recorded minimum biological yield (T_1) (2748 kg ha^{-1}).

4.4.8 Harvest index (%)

Highest harvest index was recorded with application of vermicompost 2.5 t ha^{-1} (43.75%)(T_7) and lowest harvest index is found in control (40.57%)(T_1). The mean harvest index was 41.38%.

4.5 Chemical analysis

4.5.1 pH (1:2.5)

The data pertaining to the pH in soil after harvest of chickpea is presented in Table 22 and also graphically predicted in Fig. 16 (a)

It is the negative logarithm of hydrogen ion concentration which indicates the acidity or alkalinity of soil. pH of soil was found statistically significant due to application of compost. The higher value of pH was recorded in control (T_1) treatment. Significantly lower pH was recorded with vermicompost 2.5 t ha^{-1} (T_7).

Table 22. pH, electrical conductivity (dS m^{-1}) and organic carbon (g kg^{-1}) of soil after harvest as influenced by various treatments.

Treatment		pH	EC (dS m^{-1})	OC (g kg^{-1})
T_1	Control	8.25	0.31	4.8
T_2	BD compost 5 t ha^{-1}	8.19	0.30	5.2
T_3	T_2 + soil conditioner 500	8.16	0.29	5.3
T_4	T_2+ soil conditioner 501	8.14	0.27	5.5
T_5	T_2 + soil conditioner 500 + 501	8.11	0.25	5.6
T_6	FYM 5 t ha^{-1}	8.13	0.30	5.4
T_7	Vermicompost 2.5 t ha^{-1}	8.09	0.24	5.7
S.E (m) ±		0.03	0.011	0.010
CD at 5 %		0.10	0.03	0.03
GM		8.15	0.28	5.35
Initial status		8.26	0.32	5.4

The slightly pH was decrease might be due to direct incorporation of organic sources was undergone decomposition and released of organic acid like carbonic acid and add organic matter to the soil. Similar finding was reported by Tharmaraj *et.al*. (2010).

4.5.2 Electrical conductivity (dS m^{-1})

The data pertaining to the EC in soil after harvest of chickpea is presented in Table 22 and also graphically predicted in Fig. 16 (b)

EC is a measure of soluble salt concentration in soil. The higher amount of salts in the soil restricts the nutrients uptake and thus affects the plant growth. The lower electrical conductivity (0.24 dSm^{-1}) was recorded with application of vermicompost 2.5 ton ha^{-1} (T_7)

The vermicompost will leave some acidic effect which not only nullifies negative effect of salinity but also improve availability and translocation of nutrient in system. Similar finding was reported by Tharmaraj *et.al*. (2010).

4.5.3 Organic carbon (g kg^{-1})

The data pertaining to the organic carbon content in soil after harvest of chickpea is presented in Table 22 and also graphically predicted in Fig. 16 (c) of soil as significantly influenced by application of compost. The highest organic carbon was recorded with application of vermicompost 2.5 t ha^{-1} (5.7 g kg^{-1}) (T_7) as compare to the control (4.8) (T_1).

The slightly O.C. was increased as compared to initial due incorporation of organic sources was undergone decomposition and released of organic acid like carbonic acid and add organic matter to the soil. Singh *et al.* (2014) reported that similar result.

Available nitrogen, phosphorus, potassium in the soil after harvest

The data on available nutrient status of soil influenced by various treatment are presented in Table 23 and graphically illustrated in Fig 17. The mean of available N, P and K was found 210.63, 13.86 and 309 kg ha^{-1} respectively in soil after harvest of chickpea crop.

4.5.4 Available Nitrogen

The maximum available nitrogen status of soil after harvest of chickpea was significantly increased with the use of organic sources. The available nitrogen in soil varied from 207 to 221.09 kg ha^{-1} indicating that soil was low in available nitrogen.

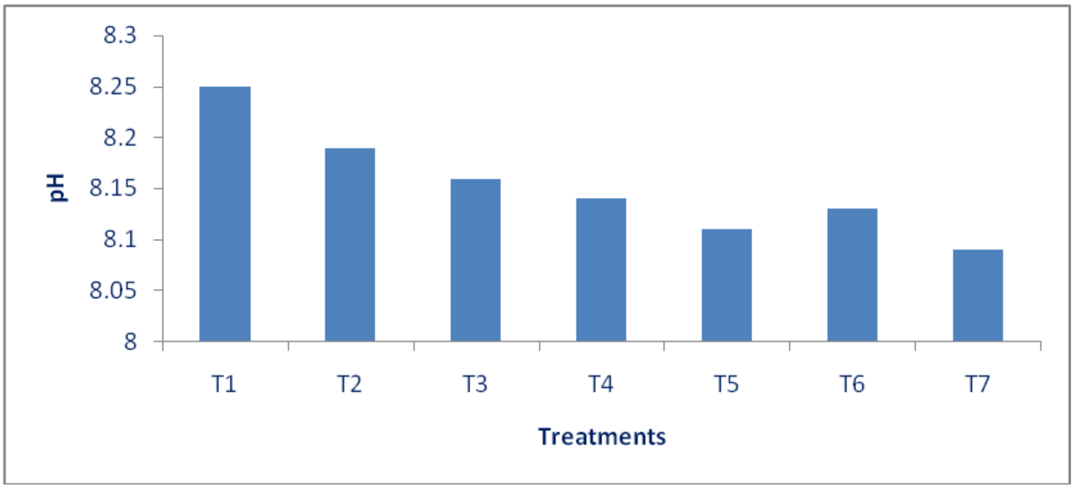

Fig. 16(a). pH of soil after harvest as influenced by various treatments

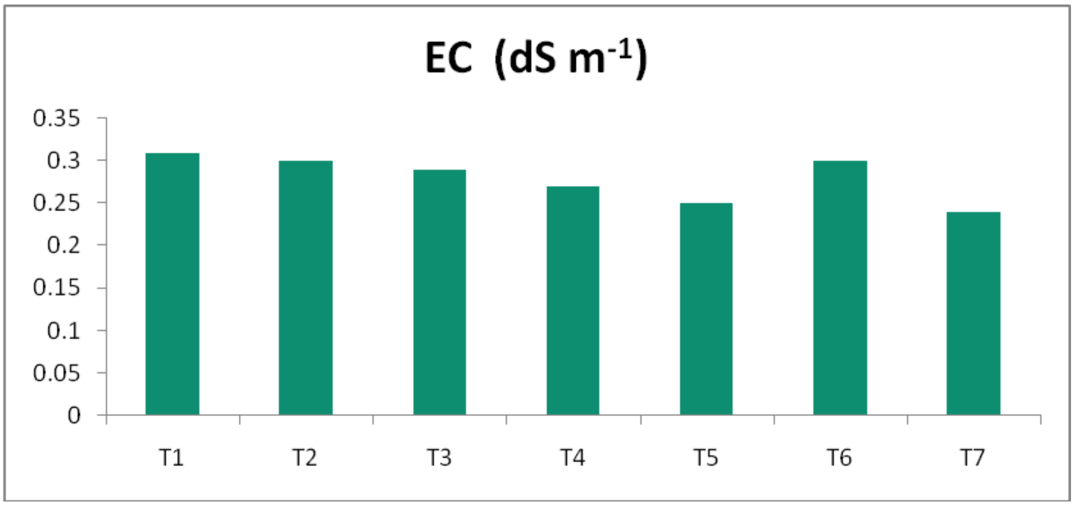

Fig. 16(b). EC (dS m^{-1}) of soil after harvest as influenced by various treatments

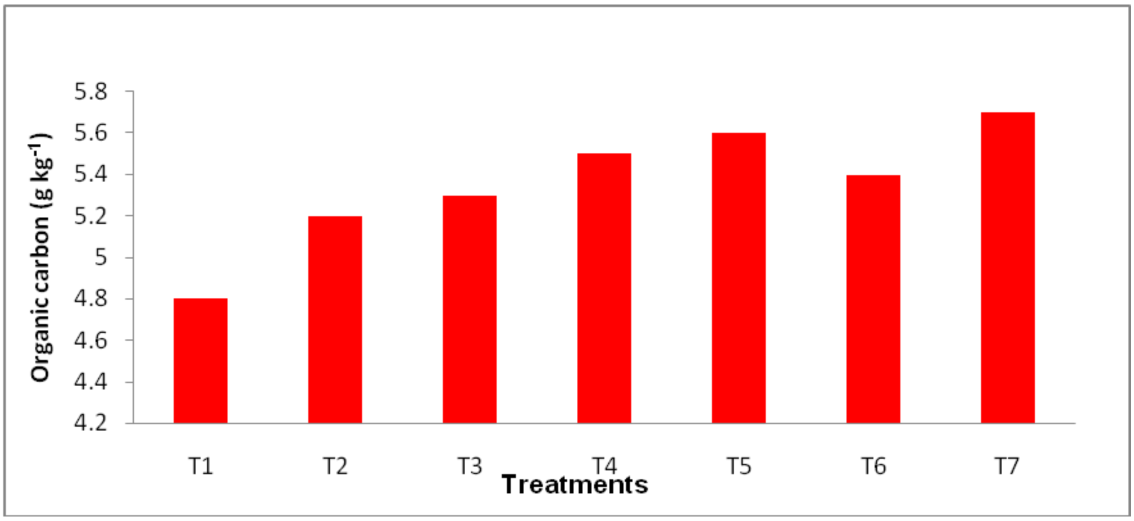

Fig.16 (c). Organic carbon (g kg^{-1}) of soil after harvest as influenced by various treatments

The maximum available nitrogen (221.09 kg ha^{-1}) was observed with application of vermicompost 2.5 t ha^{-1} (T_7) and lower values of available nitrogen found in control.

The favorable condition under vermicompost addition might have help in the mineralization of Nitrogen. Addition of organic sources, availability of nutrient increased some extended as a compare to initial due to mineralization of native soil as well as own nutrients contents when added. Similar result was reported by Singh *et*. *al.* (2014) and Kademani *et. al.* (2003).

4.5.5 Available phosphorus

It is evident from Table 23 that available phosphorus content of soil varied significantly and it ranged from 13.63 to 17.29 kg ha^{-1}. Indicating that soil was low in available phosphorus content.

Table 23. Available nitrogen, phosphorus and potassium as influenced by various treatments

Treatment		Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T_1	Control	207.00	13.63	306.90
T_2	BD compost 5 t ha^{-1}	214.84	14.80	312.36
T_3	T_2 + soil conditioner 500	213.14	14.57	314.66
T_4	T_2+ soil conditioner 501	216.41	15.60	316.55
T_5	T_2 + soil conditioner 500 + 501	217.68	15.85	317.84
T_6	FYM 5 t ha^{-1}	215.11	14.85	318.31
T_7	Vermicompost 2.5 t ha^{-1}	221.09	17.29	321.04
S.E (m) ±		1.44	0.62	1.32
CD at 5 %		4.44	1.93	4.08
GM		215.04	15.23	315.98
Initial status		210.63	13.86	309.54

4.5.6 Available potassium

The highest available potassium was found with application of vermicompost 2.5 t ha^{-1} (321.04 kg ha^{-1}) (T_7) which was at par with BD compost 5 t ha^{-1} + soil conditioner 500+ 501. (317.84 kg ha^{-1}) (T_5) and lowest value of available potassium was noticed in control (306.90 kg ha^{-1}) (T_1).

4.5.7 Nutrient content and uptake by chickpea

4.5.8. Nitrogen content in seed and straw (%)

The data presented in Table 24. revealed that, the nitrogen content. The mean N content was 2.77% and 1.54% in seed and straw respectively. There is no significance difference occur in nitrogen content in grain and straw due to application of compost.

4.5.9 Nitrogen uptake (kg ha^{-1})

The data in respect to nitrogen uptake by grain, straw and total uptake is presented in Table 24 and graphically depicted in Fig.18.

Nitrogen uptake by the crop was found to be significantly influenced by various organic sources. Maximum nitrogen uptake was found with treatment vermicompost 2.5 t ha^{-1} T_7 (109.89 kg ha^{-1}) which was at par withT_2 + Soil conditioner 500 + 501 (T_5) (108.25 kg ha^{-1}) and The minimum nitrogen uptake was found in control (T1).

Table 24. Nitrogen content and its uptake by chickpea as influenced by various treatments

Treatments		N content (%)		N uptake (kg ha^{-1})		
		Seed	Straw	Seed	Straw	Total
T_1	Control	2.67	1.42	43.61	23.19	66.80
T_2	BD compost 5 t ha^{-1}	2.66	1.46	56.99	31.18	88.17
T_3	T_2 + soil conditioner 500	2.74	1.48	60.41	32.84	93.25
T_4	T_2+ soil conditioner 501	2.80	1.58	65.39	37.08	102.47
T_5	T_2 + soil conditioner 500 + 501	2.81	1.62	68.76	39.49	108.25
T_6	FYM 5 t ha^{-1}	2.75	1.54	57.50	32.37	89.87
T_7	Vermicompost 2.5 t ha^{-1}	2.99	1.65	70.64	39.25	109.89
SE (m) ±		0.13	0.05	3.61	2.65	5.83
CD at 5%		NS	NS	11.13	8.18	17.99
GM		2.77	1.54	60.47	33.63	94.10

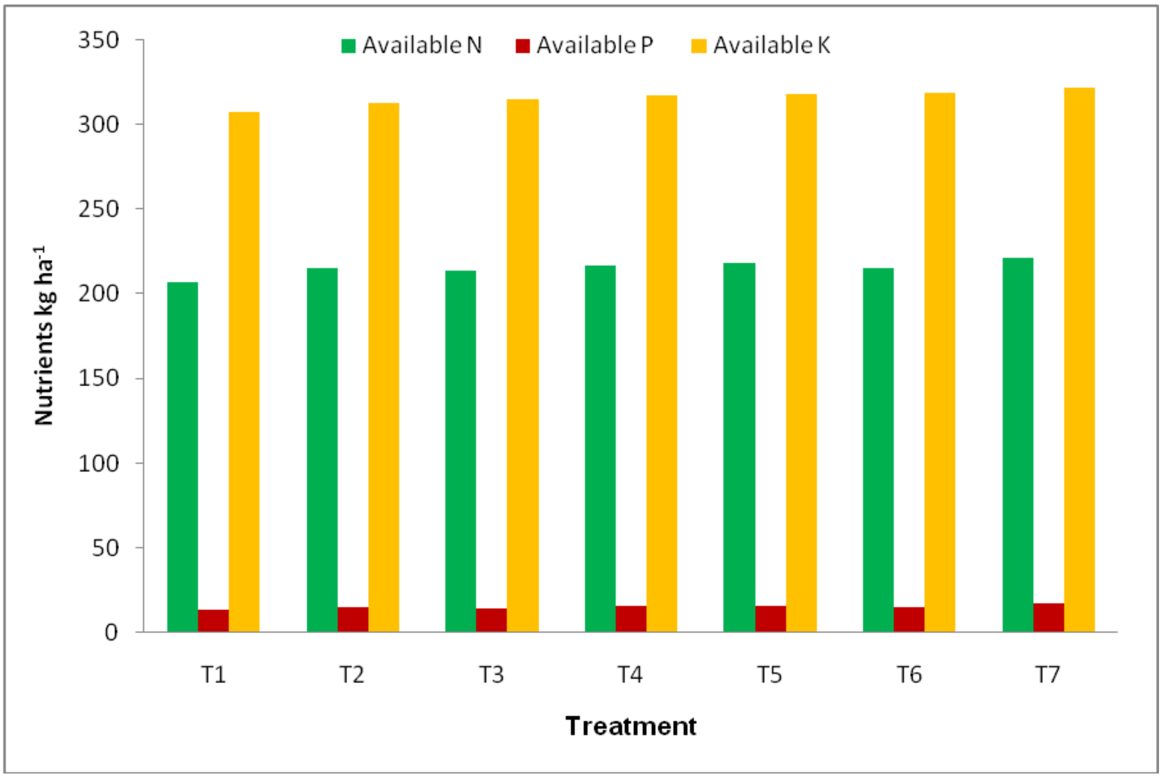

Fig.17. Available nitrogen, phosphorus and potassium as influenced by various treatments

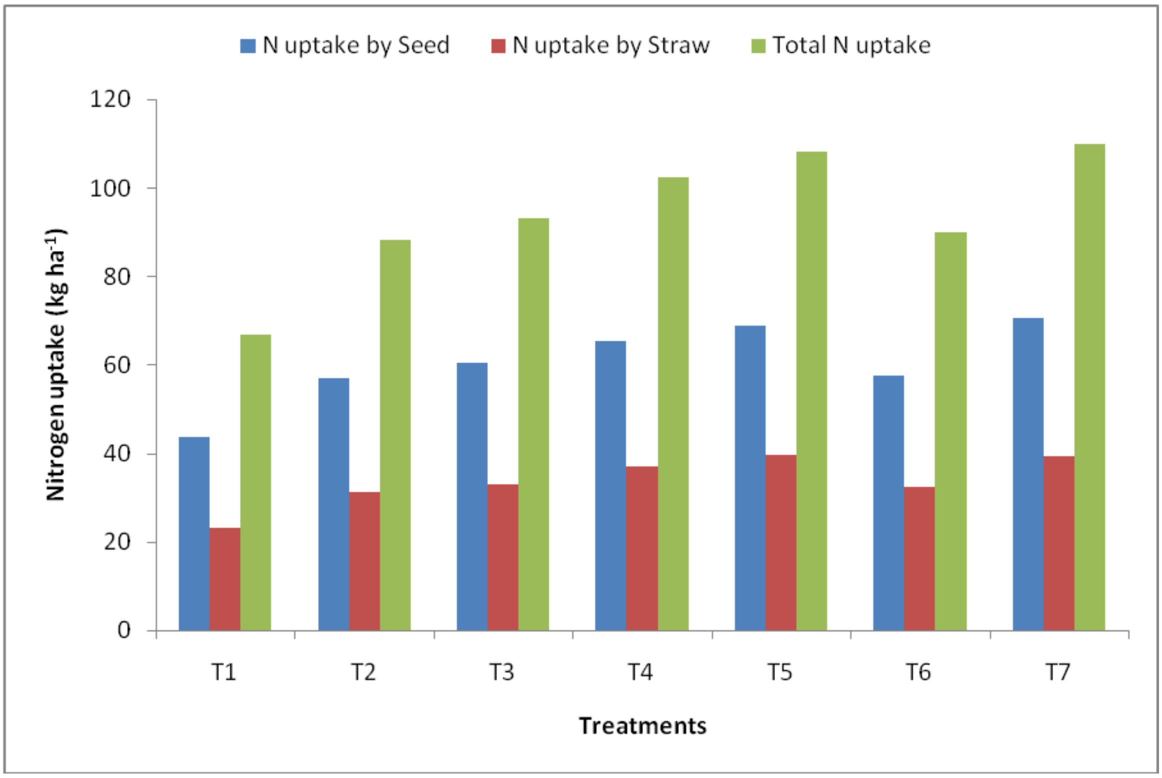

Fig.18.Nitrogen content and its uptake by chickpea as influenced by various treatments

The higher uptake of nitrogen might be due reported that microorganisms in the worm casts may fix atmospheric N in quantities that are significant for the earthworm metabolism and as a source of nitrogen for plant growth. The present findings corroborate with that of Jat and Ahlawat (2004) and singh *et. al.* (2014).

4.5.10 Phosphorus content in seed and straw

The data presented in Table 25 revealed that, the values of nitrogen content. The mean phosphorus content in grain and straw was 0.31% and 0.21% respectively. There is no significance difference occur in phosphorus content in grain and straw due to application of compost.

4.5.11 Phosphorus uptake (kg ha^{-1})

The data in respect to phosphorus uptake by grain, straw and total uptake is presented in Table 25 and graphically depicted in Fig.19.

Table 25. Phosphorus content and its uptake by chickpea as influenced by various treatments

Treatment		P content (%)		P uptake (kg ha^{-1})		
		Seed	Straw	Seed	Straw	Total
T_1	Control	0.28	0.17	3.08	2.83	5.90
T_2	BD compost 5 t ha^{-1}	0.29	0.18	4.31	3.92	8.23
T_3	T_2 + soil conditioner 500	0.29	0.20	4.39	4.52	8.91
T_4	T_2+ soil conditioner 501	0.31	0.21	4.89	4.89	9.79
T_5	T_2 + soil conditioner 500 + 501	0.33	0.23	5.66	5.70	11.36
T_6	FYM 5 t ha^{-1}	0.32	0.21	4.93	4.45	9.38
T_7	Vermicompost 2.5 t ha^{-1}	0.34	0.25	6.24	5.83	12.07
S.E (m) ±		0.02	0.018	0.37	0.54	0.54
CD at 5%		NS	NS	1.15	1.68	1.67
GM		0.31	0.21	4.79	4.59	1.67

Phosphorus uptake by the crop was found to be significantly influenced by various organic sources. Maximum phosphorus uptake was found with treatment vermicompost 2.5 ton ha^{-1} (T_7) (12.07 kg ha^{-1}) over rest of treatments and The minimum nitrogen uptake was found in control (5.90 kg ha^{-1}) (T_1).

This result might be due the progressively released nutrients by vermicompost into the rhizosphere provide the appropriate conditions for plant uptake and exchangeable P in vermicompost are present in readily available forms for plant uptake. Singh *et. al*. (2014) have also reported the similar result for increasing phosphorus uptake.

4.5.12 Potassium content in grain and straw

Potassium uptake in grain, straw and total uptake is presented in Table 26. The mean potassium content in grain and straw was 1.07 % and 1.41% respectively. There is no significance difference occur in potassium content in grain and straw due to application of compost.

4.5.13 Potassium uptake (kg ha^{-1})

Phosphorus uptake in grain, straw and total uptake is presented in Table 26 and graphically depicted in Fig.20.

Table 26. Potassium content and its uptake by chickpea as influenced by various treatments

Treatment		K content (%)		K uptake (kg ha^{-1})		
		Seed	Straw	Seed	Straw	Total
T_1	Control	1.03	1.31	11.49	21.41	32.90
T_2	BD compost 5 t ha^{-1}	1.05	1.33	15.58	28.48	44.06
T_3	T_2 + soil conditioner 500	1.06	1.37	16.01	30.43	46.44
T_4	T_2+ soil conditioner 501	1.08	1.39	17.13	32.73	49.86
T_5	T_2 + soil conditioner 500 + 501	1.09	1.51	18.85	36.94	55.79
T_6	FYM 5 t ha^{-1}	1.05	1.38	16.02	29.22	45.24
T_7	Vermicompost 2.5 t ha^{-1}	1.14	1.60	21.05	37.80	58.85
S.E (m) ±		0.05	0.07	1.67	3.13	4.13
CD at 5%		NS	NS	5.17	9.96	12.74
GM		1.07	1.41	16.59	31.00	47.59

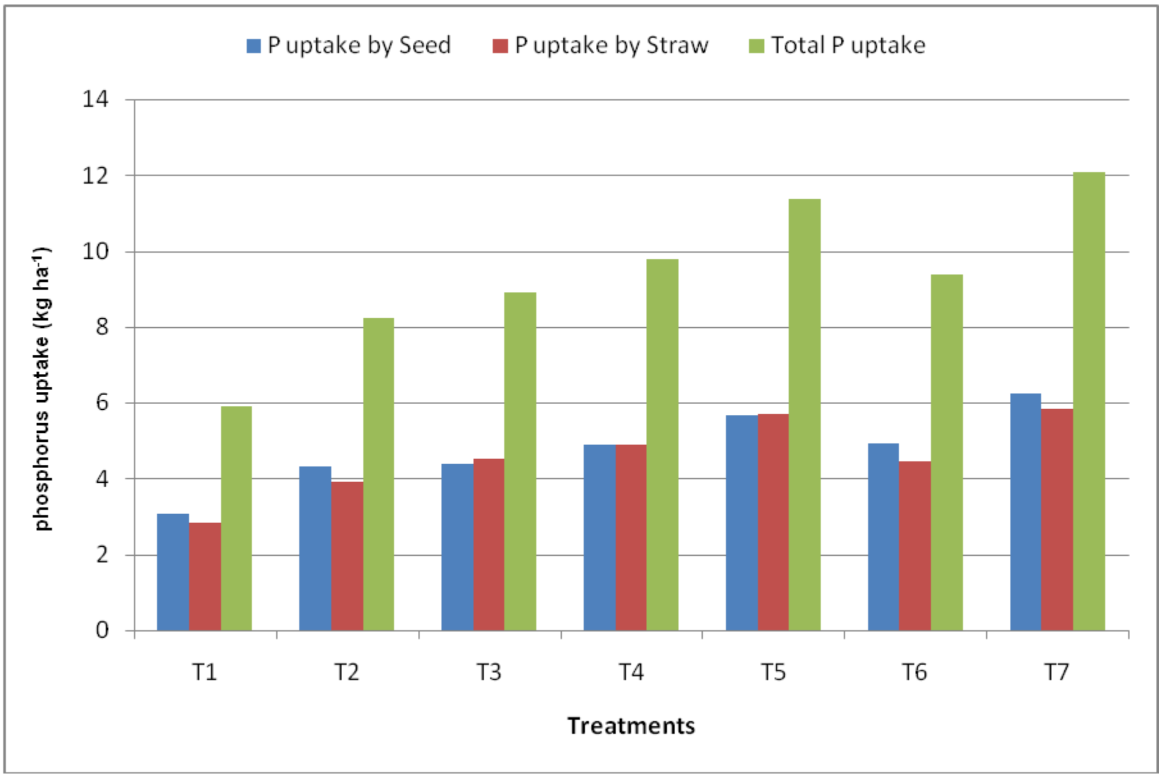

Fig.19. Phosphorus content and its uptake by chickpea as influenced by various treatments

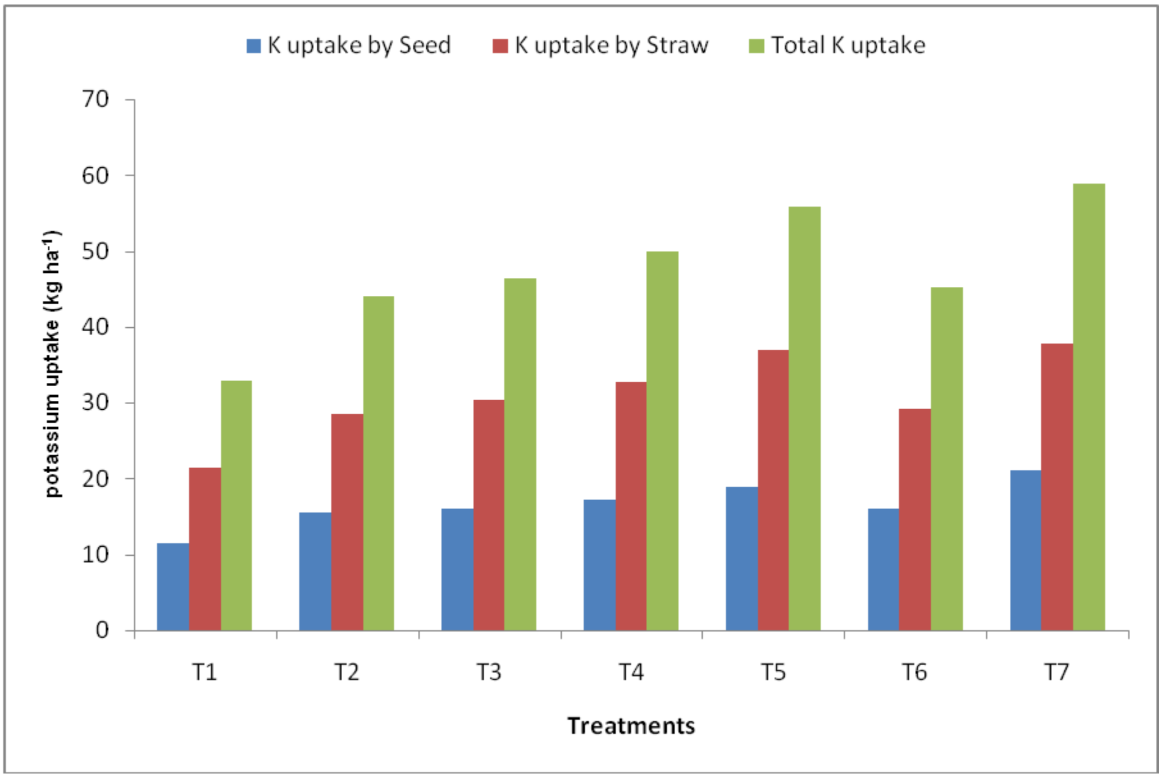

Fig. 20. Potassium content and its uptake by chickpea as influenced by various treatments

Maximum potassium uptake was found with treatment vermicompost 2.5 ton ha^{-1} (58.85 kg ha^{-1}) (T_7) which was at par with followed by BD compost + soil conditioner 500 + 501 (T_5). The minimum nitrogen uptake was in control (T_1).

4.6. Quality studies

4.6.1 Protein content in chickpea seed

The data pertaining to protein content in chickpea was given in Table 27. It was observed that, protein content not significantly influenced due to various treatments. The mean value of protein content was 17.33%.

Table 27. Protein content of chickpea as influenced by various treatments

Treatment		Protein content (%)
T_1	Control	16.68
T_2	BD compost 5 t ha^{-1}	16.63
T_3	T_2 + soil conditioner 500	17.13
T_4	T_2+ soil conditioner 501	17.50
T_5	T_2 + soil conditioner 500 + 501	17.56
T_6	FYM 5 t ha^{-1+}	17.19
T_7	Vermicompost 2.5 t ha^{-1}	18.63
S.E (m)±		0.39
CD at 5%		NS
GM		17.33

4.7. Biological properties

4.7.1 Microbial study

It well know fact that soil harbors a vast of living organisms. Application of organic nutrients sources favorably help in augmentation of beneficial microbial population in soil and their activity such as organic matter decomposition, biological nitrogen fixation and availability of all plant nutrients.

Table 28. Microbial count (CFU g^{-1} soil) in rhizosphere of chickpea as influenced by various treatments

Treatment		Bacteria 10^7 CFU g^{-1} soil	Fungi 10^4 CFU g^{-1} soil	Actinomycetes 10^6 CFU g^{-1} soil
T_1	Control	26	13	19
T_2	BD compost 5 t ha^{-1}	29	15	22
T_3	T_2 + soil conditioner 500	36	19	24
T_4	T_2+ soil conditioner 501	30	14	20
T_5	T_2 + soil conditioner 500 + 501	37	20	27
T_6	FYM 5 t ha^{-1}	30	16	23
T_7	Vermicompost 2.5 t ha^{-1}	39	23	29
GM		32	17	23

Microbial count in rhizosphere of chickpea as influenced by various treatments is presented in Table 28 and graphically depicted in Fig.21. The highest count of bacteria, fungi and actinomycetes was found with application of vermicompost 2.5 t ha^{-1} (T_7) and lowest microbial population in control (T_1)

4.8. Economic studies

Data in respect to cost of cultivation, gross monetary returns (GMR), net monetary returns and benefit cost ratio (B:C ratio) as influenced by organic sources for chickpea are presented in Table 29 and graphically depicted in Fig.22.

4.8.1 Cost of cultivation (`. ha^{-1})

The cost of cultivation was found to be lowest in control plot because of expenditure on source of organic manure was not done.

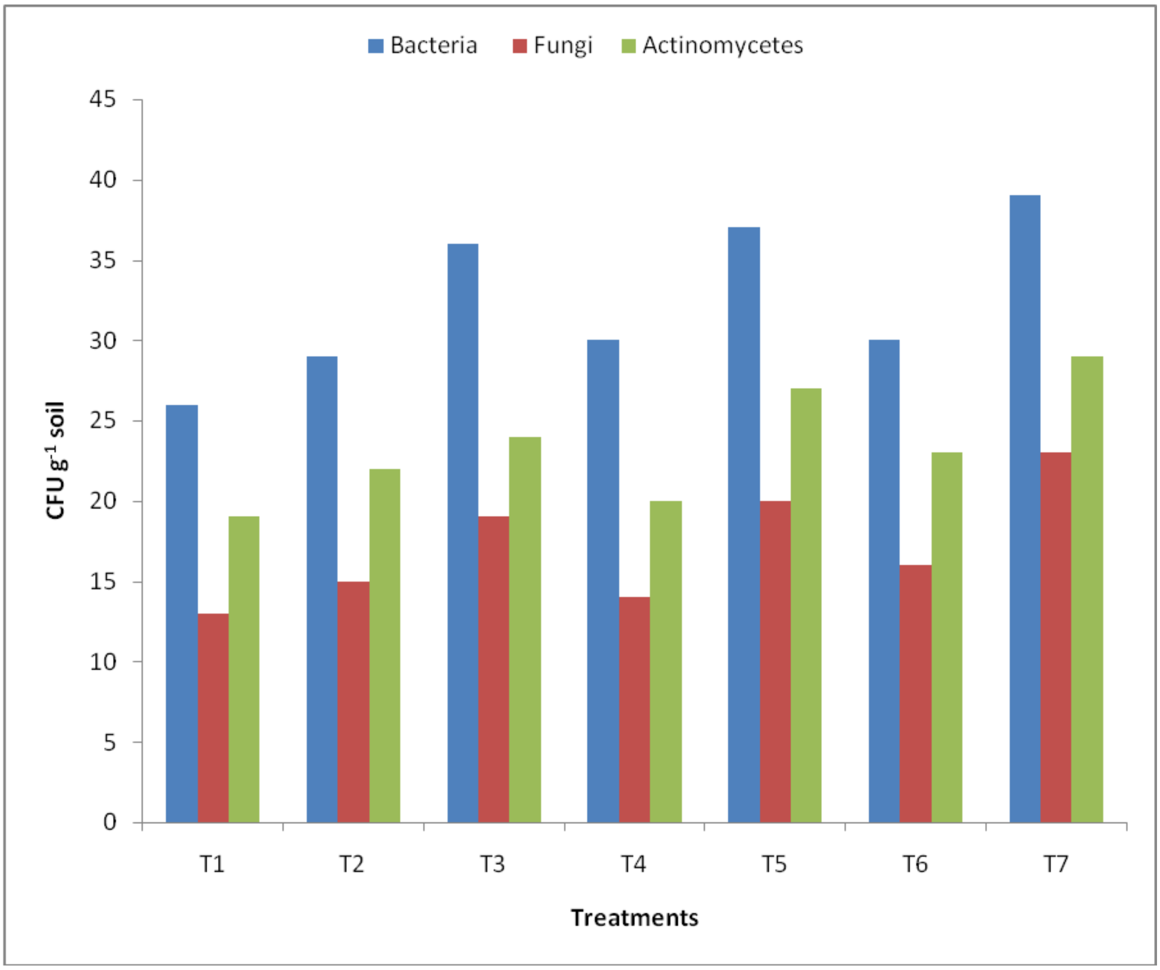

Fig.21. Microbial count (CFU g^{-1} soil) in rhizosphere of chickpea as influenced by various treatments

4.8.2 Gross monetary returns (`. ha^{-1})

The Gross monetary return calculation was done on basis of MSP of chickpea. Gross monetary return (GMR) was significantly influenced by different treatments.

vermicompost 2.5 t ha^{-1}(T_7) recorded highest gross monetary return (85689 `. $ha^{-1}$) which was at par with $T_2$ + soil conditioner 500 + 501 (79907 `. ha^{-1}) (T_5) and minimum gross return (52326 `. ha^{-1}) was found in control because of lowest yield (T1).

Table 29. Cost of cultivation, Gross monetary returns, Net monetary returns and Benefit: Cost ratio as influenced by treatments

Treatment		COC (` ha^{-1})	GMR (` ha^{-1})	NMR (` ha^{-1})	B:C ratio (%)
T_1	Control	20741	52326	31585	2.52
T_2	BD compost 5 t ha^{-1}	38347	69742	31395	1.82
T_3	T_2 + soil conditioner 500	38827	71002	32175	1.83
T_4	T_2+ soil conditioner 501	38927	74250	35323	1.91
T_5	T_2 + soil conditioner 500 + 501	39177	79907	40730	2.04
T_6	FYM 5 t ha^{-1}	35741	71672	35931	2.01
T_7	Vermicompost 2.5 t ha^{-1}	29491	85689	56198	2.91
S.E (m) ±		-	4177	4177	-
CD at 5%		-	12872	12872	-
GM		-	72084	37619	2.14

4.8.3 Net monetary returns (`. ha^{-1})

A net monetary return is depend on gross return and cost of cultivation. Gross monetary return (GMR) was significantly influenced by different organic sources of nutrient. vermicompost 2.5 t ha^{-1} (56198 `

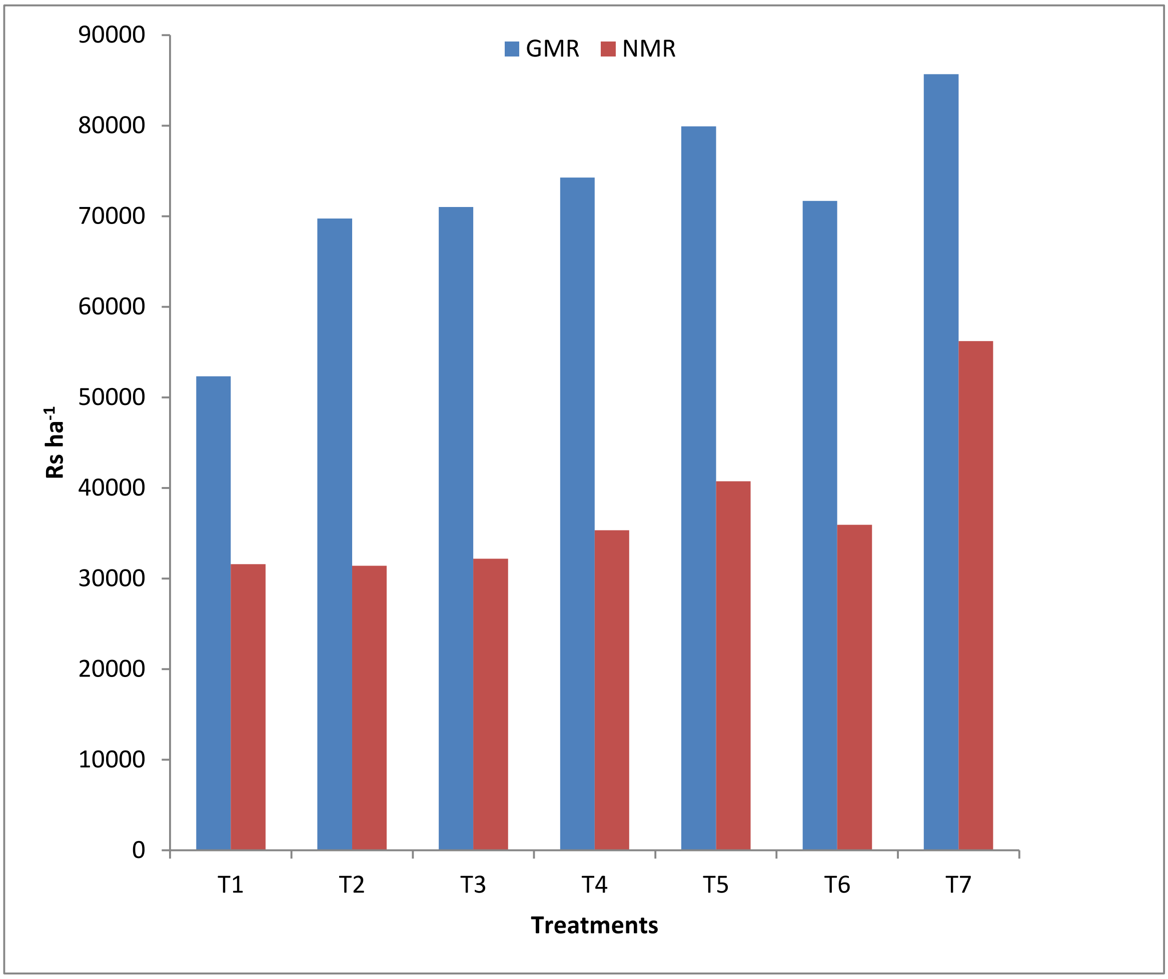

Fig.22. Gross monetary returns and Net monetary returns as influenced by various treatments

ha^{-1}) (T_7) recorded maximum net monetary returns and lowest net monetary returns was found in BD compost 3 t ha^{-1} (31395 ` ha^{-1}).

B:C Ratio

The highest benefit-cost ratio was registered with application of vermicompost 2.5 t ha^{-1} (2.91) (T_7) which was however higher among various organic sources.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment entitled, "Comparative study of conventional and biodynamic compost on performance of organic chickpea", was carried out at Agronomy farm section during *rabi* 2017-18.

The soil of experimental plot was clayey in texture. It was low in available nitrogen and phosphorus and medium in organic carbon, high in available potassium and alkaline in reaction. The chickpea variety (JAKI-9218) was sown on 6^{th} November 2017 and harvested at 22^{nd} February 2018. The experiment was laid out in randomized block design with seven treatments and three replications. The gross plot size was 5.60 m x 6 m. Treatments consisted of application of compost *viz*., Control (T_1), BD compost 5 t ha^{-1} (T_2), T_2 + Soil conditioner 500 (T_3), T_2 + Soil conditioner 501 (T_4), T_2 + Soil conditioner 500+ 501 (T_5), FYM 5 t ha^{-1} (T_6) and Vermicompost 2.5 t ha^{-1} (T_7).

5.1 Effect of compost application

5.1.1 Growth character

The difference in growth character were not marked significant at 20 DAS as the crop is in advanced age significant difference from 40 DAS were observed and continue to be significant till harvest. Growth attributes viz., plant height, number of branches, number of leaves, leaf area, dry matter accumulation and canopy spread was maximum with treatment of vermicompost application at 2.5 t ha^{-1} (T_7) which was at par with T_2 + Soil conditioner 500 + 501 (T_5).

5.1.2 Root study

Root studies *viz*., number of root nodules $plant^{-1}$, root length $plant^{-1}$, root weight $plant^{-1}$, root volume $plant^{-1}$ were significantly maximum at 60 DAS and 90 DAS except at 30 DAS with application of vermicompost 2.5 t ha^{-1} (T_7) which was at par with T_2 + Soil conditioner 500 + 501 (T_5).

5.1.3 Yield attributes and yield

Yield attributes *viz*., number of pod plant^{-1} (34.95), pod weight plant^{-1} (14.90 g), seed weight plant^{-1} (12.10 g) and seed yield (1840 kg ha^{-1}), straw yield (2365 kg ha^{-1}) and biological yield (4205 kg ha^{-1}) were recorded significantly maximum with vermicompost application 2.5 t ha^{-1} which was at par with T_2 + Soil conditioner 500 + 501 (T_5).

5.1.4 Nutrient status of soil

Among chemical properties pH, EC, organic carbon and available NPK were studied during experimentation. The mean pH value of the soil was 8.15, which is significantly lowered with application of compost. The average EC of the field 0.28 dS m^{-1} which was significantly decreased in with application of compost. Organic carbon was significantly influenced with the application of compost. Available NPK was found significantly maximum in treatment Vermicompost 2.5 t ha^{-1} but it was at par with the T_2 + Soil conditioner 500 + 501 (T_5).

5.1.5 Biological properties

The microbial *viz*., fungi, bacteria, actinomycetes population in rhizosphere of chickpea was found maximum with application of vermicompost 2.5 t ha^{-1}. However, the minimum microbial population in rhizosphere of chickpea was recorded with the control (T_1).

5.1.6 Economics

Gross monetary return, net monetary return and benefit cost ratio were significantly highest with application of vermicompost at 2.5 t ha^{-1} (T_7).

5.2 Conclusion

On the basis of result obtained from present investigation following conclusion are drawn

- Application of vermicompost 2.5 t ha^{-1} recorded significantly higher growth parameter, yield attributes and yield in chickpea.
- The chemical and biological properties of soil improved by organic production system in chickpea crop.

- Economic returns was found profitable in terms of gross monetary return, net monetary return and B:C ratio with application of vermicompost 2.5 t ha^{-1}.

In general application of vermicompost 2.5 t ha^{-1} shows superior growth, productivity, root studies and economics of chickpea crop production over all the parameters studied in the experiment. These conclusions are based on the result of one year investigation and therefore further detail experimentation is needed to arrive at valid recommendation.

CHAPTER VI

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Place : Akola

Date : / /2019

(Bayskar Akshay Satish)

Signature of Student

APPENDIX - I

Cost of inputs

Sr. No.	Particulars	Rates (`.)
1	Vermicompost kg^{-1}	3.50
2	FYM kg^{-1}	2.50
3	BD compost kg^{-1}	3.50
4	Rhizobium kg^{-1}	42
5	PSB kg^{-1}	50
6	Cost of seed (`. kg^{-1})	75
7	S9 culture (`. kg^{-1})	150
8	BD 500 (30 gm)	250
9	BD 501 gm^{-1}	250

APPENDIX - II

Working cost

Sr. No.	Particulars	Rates (`.)
1	Male day^{-1}	230
2	Female day^{-1}	230
3	Bullock pair day^{-1}	1000

APPENDIX - III

Cost of output

Market value of chickpea seed and straw (per quintal) as recommended by Agricultural Produce Market Committee (APMC): `. 4400/- for seed and 200/- for straw