NUTRIENT MANAGEMENT IN CHICKPEA (*Cicer arietinum L.*) IN BLACK SOIL UNDER RAINFED SITUATION

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By

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CERTIFICATE

This is to certify that the thesis entitled **"NUTRIENT MANAGEMENT IN CHICKPEA (*Cicer arietinum* L.) IN BLACK SOIL UNDER RAINFED SITUATION"** submitted by **Mr. TIRUPATI METI** in partial fulfillment of the requirement for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **SOIL SCIENCE AND AGRICULTURAL CHEMISTRY,** College of Agriculture, Raichur, University of Agricultural Sciences, Raichur, is a record of research work done by him during the period of his study in this University under my guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or other similar titles.

Raichur

December, 2017

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(PANDITH RATHOD)

Affectionately dedicated

To

My Beloved Parents,

Family and Friends

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Gratitude takes three forms, "A feeling from the heart, an expression in words and a giving in return............."

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LIST OF SYMBOLS AND ABBREVIATIONS

%	:	per cent
^{o}C	:	degree celsius
CD (P=0.05)	:	critical difference at 5 per cent level
cm	:	centimeter
DAP	:	Dai Ammonium Phosphate
DAS	:	Days after Sowing
dS m^{-1}	:	deciseimen per metre
EC	:	Electrical conductivity
et al.	:	and others people
Fig.	:	Figure
g	:	Gram(s)
ha	:	Hectare
HI	:	Harvest Index
i.e.,	:	which is to say, in other words
K	:	potassium
kg	:	kilogram
l	:	Litre
m	:	metre
mg	:	milligram
N	:	nitrogen
NS	:	non significant
OC	:	organic carbon
P	:	phosphorus
ppm	:	parts per million
Rs ha^{-1}	:	Rupees per hectare
S	:	Sulphur
S.Em+	:	Standard error of mean
viz.,	:	namely

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I. INTRODUCTION

A strong and prosperous agriculture is necessary for the economic growth and development of the country. Agriculture is one of the oldest and most prospective professions of human civilization whose prosperity depends on soil organic matter status. The Green revolution technologies involving greater use of synthetic agrochemicals such as fertilizers and pesticides with adoption of nutrient- responsive, high- yielding varieties of crops from mid 1960's onwards no doubtely boosted the food grain production but also the soil system appeared to show signs of exhaustion after two to three decades, thus reflecting decline in the overall productivity per unit area of most of the crops. Inspite of using modern technologies, the yield did not show the same upward trend and it continued ever today itself.

In future days, the food requirement would increase and parallel the external inputs (fertilizer, pesticides *etc*) too. In turn, the situation will also pose challenge of feeding the people to the desired extent with right quality of safe food. In this context, adoption of organic farming is a remedy to cure the ill effects of modern chemical agriculture. Good tenets of soil building, increasing its carbon contents and adopting good traditional practices of using on-farm inputs or raising crops are receiving increased attention. Use of green manure, augmenting bio-mass, preparing good enriched organic manures and adopting bio-control measures to manage pests and diseases are expected to help to maintain good health with adequate production of crops that are safe and healthy.

Among the various factors affecting the growth and yield of crops, nutrient management plays a vital role. In crop production, chemical fertilizers are the major source of nutrients, but escalating cost, coupled with increasing demand of chemical fertilizers and depleting soil health necessitates the safe and efficient use of organics in crop production, which is gaining much popularity. It helps to enhance and maintain soil organic carbon status for sustained crop yield. The total nutritional consumption from chemical fertilizers is about 128.08 tons in India (Anon., 2014-15). To augment this, India is endowed with enormous potential of biological resources and industrial byproducts. According to Katyal (2000), India with the second largest human population which is sustained seventh largest geographical area in the world with tropical and sub-tropical climate with highest number of livestock, offers a great potential for organic matter availability. However, under aerable production systems, organic manures suffer from the drawback of slow release of nutrients, which may cause significant reduction in crop yield and net farm income. This could be overcome by use of judicious combination of organic manures. Combined application of green manures, crop residues and composts along with liquid manures mainly jeevamrutha, panchagavya, bio-digester solution, beejamrutha, biogas spent slurry and vermiwash, etc. in a more synchronized system can release the nutrients as per the need of crop to sustain higher productivity (Kanwar *et al.*, 2006(a)).

Organic farming gives major emphasis on recovery and maintenance of soil fertility and for sustainable yield. Organic farming helps to improve the physical, chemical and biological properties of soil and maintains the ecological balance as well as productivity of life supporting systems for the future generations. Organic farming is gaining momentum all over the world as it addresses self-reliance in food, rural development and conservation of natural ecosystem and sustained biodiversity (Pathak and Ram, 2006). Due to increasing health conscious in recent years, organic products have gained niche position in global food market (100 billion $) particularly in developed countries. Organic farming has become a truly exiting and dynamic sector of the food industry.

Organic manures in agriculture add much needed organic and mineral matter. Organic systems rely on management of organic matter to enhance the soil fertility and productivity. Organic matter has an over whelming effect on almost all soil properties. Organic matter a most precious component is also considered as store house of many nutrients. For mineralization of organic matter, soil fauna and microorganisms are indispensible. Soil harbours a dynamic microbial population, arthropods and others (soil biota). The living phase of soil is greatly stimulated by organic manure addition which serves as a food (carbon) and energy source for soil life. Both soil and enzyme systems are associated with organic manure management which carries out a wide range of processes that are important for soil health and fertility. The proper management of these makes it possible to increase the efficiency of use of soil and added nutrient (Ramesh, 2007).

In this context, it is worth noting that nutrient management through organics plays a major role in maintaining soil health due to build up of soil organic matter, beneficial microbes, enzymes, besides improving soil physical and chemical properties. To achieve the sustained soil fertility and crop productivity the role of organic manures and other nutrient management practices like use of fermented organic nutrient like, jeevamrutha, beejamrutha, panchagavya, cow urine, bio-digester solution etc, are very important. These fermented liquid organic manures, contain in additions to nutrients they have microbial load and growth promoting substances which helps in improving the plant growth, metabolic activity and resistance to pest and diseases.

Pulse crops play an important role in Indian agriculture. Besides being rich in protein, they sustain the productivity of cropping systems. Their ability to use atmospheric nitrogen through biological nitrogen fixation (BNF) is economically more sound and environmentally acceptable. Pulses constitute an important ingredient in predominantly vegetarian Indian diet. Cereals constitute the staple food and the major source of energy, while the addition of pulses, which are the main source of vegetable proteins provide nutritionally balanced food. On an average, pulses contain 20 to 25% protein on dry seed basis, which is almost 2.5 to 3.0 times of the value normally found in cereals.

Chickpea is the premier pulse crop grown in *rabi* mainly under rainfed condition. Along with pigeonpea, it is the main source of dietary protein for the majority of Indian population. Chickpea remarkably predominates among other pulse crops in terms of area and production. As per the latest report of Food & Agriculture Organization (FAO) for 2012-13, India is the largest producer and consumer of chickpeas in the world. The Karnataka stands 5th position in both area and production, productivity is low (643 kg ha^{-1}) as compare to national average (1036 kg ha^{-1}).

In north eastern dry zone of Karnataka, chickpea is one of the important rainfed crop grown during *rabi* season. This crop requires low input requirement particularly with response to nutrients. The yield level of this crop is not stable and potential yield is yet to be achieved. The yield decline is mainly due to low soil fertility status. There is a need to stabilize the yield. The crop yield can be maintained on sustainable manner on long run under organic system. Hence, the present investigation was carried out with the following objectives.

1. To study the integrated effect of organic and inorganic sources of nutrient on growth and development of chickpea.
2. To study the nutrients uptake pattern in chickpea.
3. To study the effect of organic and inorganic sources of nutrients on soil microbial process.

II. REVIEW OF LITERATURE

Field investigations on “Nutrient management in chickpea (*Cicer arietinum* L.) in black soil under rainfed situation” during the *rabi,* 2016-17 were carried out at Krishi Vignana Kendra, Kalaburagi, UAS, Raichur in organic production systems maintenance of organic matter plays a key role in improving soil physical, chemical and biological properties. The related literature on the subject is classified into different sub-heads considering the objectives and treatments of the investigation are as follows:

2.1 Chemical composition of farmyard manure (FYM), vermicompost (VC) and Jeevamrutha (LM).

2.2 Effect of organic manures on growth and yield of crops.

2.3 Effect of organic manures on soil microbial activity and dehydrogenase activity.

2.4 Effect of organic manures on the availability and uptake of nutrients by crops.

2.5 Effect of organics on economics of chickpea cultivation.

2.1 Chemical composition of farmyard manure (FYM), vermicompost (VC) and jeevamrutha (LM).

2.1.1 Farmyard manure (FYM)

Farmyard manure (FYM) and composts are prepared using yard waste, animal waste and other wastes available on the farm. The process of compost preparation involves controlled decomposition of organic wastes such as remains of crop, field grasses, water hyacinth, sawdust, sugarcane trash, press mud, coir dust or pith, rural wastes and industrial waste of organic origin free of chemicals and toxic substances, city sewage, night soil *etc*., through microbial activity. These are bulky in nature and low in nutrients content, but its special merit lies in its capacity to supply large number of essential micronutrients and organic carbon in addition to NPK, which are becoming deficient in the intensively cultivated soils. Organic manures constitute a dependable source of organic matter as well as essential nutrients besides improving soil physical and biological conditions.

At Bhopal, Muneshwar Singh *et al.* (2001) reported that the nutrient content of farmyard manure was 0.62 per cent nitrogen, 0.13 per cent phosphorus, and 0.71 per cent potassium. Further, Senapati and Padhihari (2002) stated that the farm yard manure possessed 0.32 per cent N, 0.23 per cent P_2O_5 and 0.20 per cent K_2O.

Singh and Chauhan (2002) reported that the farmyard manure possessed 1.73, 0.28 and 1.02 per cent of nitrogen, phosphorus and potassium, respectively.

Singh *et al.* (2003) reported that the FYM contained 0.60 and 0.67 per cent nitrogen, 0.21 and 0.24 per cent phosphorus and 0.64 and 0.70 per cent potassium on dry weight basis in 1993 and 1994, respectively.

Ananda (2003) analyzed the farmyard manure which produced at farmer's field in Manchiganahalli, Kolar district of Karnataka and found that it contained 0.8 per cent nitrogen, 0.4 per cent phosphorus, 0.6 per cent potassium and 20.2 per cent carbon.

From, Uttaranchal, Ghosh and Singh (2003) reported that the farmyard manure contained 0.6 per cent N, 0.25 per cent P and 0.30 per cent K on dry weight basis.

In India, FYM is the most commonly used organic manure which contains 0.70-1.30 per cent N, 0.30-0.90 per cent P_2O_5 and 0.40-1.00 per cent K_2O and 24.00-40.00 per cent organic carbon depending upon the type of animals and nature of feed (Chhonkar, 2003).

Poul *et al.* (2004) conducted an experiment to study the effect of organic and inorganic nutrients on growth, yield and nutrient uptake by Tomato. In their study, they analyzed FYM for organic carbon, total N, P and K which were found to contain 17.20, 0.86, 0.32 and 0.40 per cent, respectively.

Bonde *et al.* (2004) conducted an experiment to study the effect of different organic residues on physical and chemical properties of soil in cotton soybean inter-cropping in Vertisol. They analyzed the FYM and were known to contain 0.48 per cent nitrogen, 0.25 per cent phosphorus and 0.47 per cent potassium.

Dademal and Dongale (2004) conducted an experiment to study the effect of manures and fertilizers on growth and yield of okra and nutrient availability in lateritic soils of Konkan. According to them, the FYM was reported to contain 1.18 per cent nitrogen, 0.95 per cent phosphorus and 1.09 per cent potassium.

Halemani *et al.* (2004) analyzed the different organic manures for their nutrient composition and found that the FYM contained 0.64 per cent N, 0.31 per cent P and 0.55 per cent K.

Ghuman and Sur (2006) conducted an experiment to study the effect of manuring on soil properties and yield of rainfed wheat during 1994-2000 in a loamy sand soil at the Soil Research Farm of Punjab Agricultural Univesity, Ludhiana. They analyzed and reported that the FYM on an average contained 0.60 per cent nitrogen, 1.20 per cent phosphorus and 1.30 per cent potassium.

Mohd *et al.* (2007), while studied on the effect of integrated use of farmyard manure and fertilizer nitrogen with and without sulphur on yield and quality of Indian mustard reported that FYM contain on an average 0.50 per cent N, 0.10 per cent P and 0.50 per cent potassium.

Barik *et al.* (2011) reported that the FYM contains 0.52, 0.18 and 0.23 per cent N, P and K, respectively, whereas vermicompost contains of 1.56, 0.54 and 0.61 per cent N, P and K, respectively.

2.1.2 Vermicompost (VC)

The complex organic residues are biodegraded by symbiotic association between earthworms and microbes and in this process, vermicompost or vermicastings are produced. The vermicompost apart from increasing the density of microbes also provides sufficient energy for them to remain active. Vermicompost can provide the required nutrients to the plants. It provides the vital macro nutrients such as N, P_2O_5, K_2O, Ca and Mg and micronutrients such as Fe, Mo, Zn, Cu *etc.* Apart from this, it contains plant growth promoting substances such as NAA, cytokinins, gibberelllin *etc.*

Vermicompost is an aerobically degraded organic matter, which would further be disintegrated by the enzymatic activity in the gut of earthworms and hence associated with enzymes of microbial population (Kale *et al.,* 1992).

Joshi and Prabhakara Setty (2005) reported that the vermicompost contains 0.9 to 1.0 per cent N, 0.8 per cent P and 0.6 per cent K and can successfully be used as manure rich in N, P and K as well as micronutrients in comparison with FYM.

Barik *et al.* (2011) reported that the FYM contains 0.52, 0.18 and 0.23 per cent N, P and K, respectively, whereas vermicompost contains of 1.56, 0.54 and 0.61 per cent N, P and K, respectively.

2.1.3 Jeevamrutha (LM)

According to Palekar (2006), Jeevamrut is a fermented liquid product prepared by mixing up cowdung (10.00 kg) with cows urine (10.00 litre), jaggery (2.00 kg), legume flour (2.00 kg) and handful of soil brought from the bunds of the lands where cultivation is to be taken up. Jeevamrut also contains enormous amount of microbial load which multiply and act as a soil tonic. It is said to enhance microbial activity in soil and ultimately ensuring the availability and uptake of nutrients by the crops.

Vasanthkumar (2006) reported that Jeevamrut is not a source of nutrients, but it is a fermented liquid product containing huge quantity of microbial load and which enhances soil bio-mass upon its application to soil even at very lesser rate as it act as a tonic to soil besides improving soil health.

2.2 Effect of farmyard manure, vermicompost and jeevamrutha on growth, and yield of crops.

2.2.1 Effect of farmyard manure on crop growth and yield crops.

Application of different organic sources significantly influenced the dry matter production and NPK uptake of maize in both the years over no organic sources. Among those application of enriched FYM @ 750 kg ha^{-1} enhanced the dry matter production over no application of organic sources. Higher dry matter production in these treatments was due to the taller plant and higher leaf area (Vadivel *et al.,* 1999).

Thakur *et al*. (1999) recorded higher values of yield attributes of wheat with the application of FYM 10 t ha^{-1} *viz.*, number of ear m^{-1} row length (74.22), ear head length

(8.22 cm), grains ear head^{-1} (43.33), test weight (35.11 g) and grain yield (30.62 q/ha) than no organic manure application.

In groundnut highest plant height and number of branches were recorded with application of FYM @ 6 t ha^{-1} + RDF followed by vermicompost @ 2 t ha^{-1} + RDF (Halepyati, 2001).

Six years fixed site study showed that grain and fodder yield of sorghum were higher in treatment receiving nutrients only through organics (FYM) to meet the recommended dose of fertilizer in integration with *Azotobacter* and crop residues incorporation as compared to nutrient supply through only chemical fertilizers (More and Hangarge, 2003).

Ananda *et al.* (2004) noticed that the application of 13 t ha^{-1} FYM recorded taller plants (14.1cm), total dry matter (15.7g), number of nodules per plant (62.9) and pod yield (1874 kg ha^{-1}) of groundnut followed by urban garbage compost at 11.5 t ha^{-1}.

At Nagpur on Vertisols under rainfed conditions, annual additional application of 10 t FYM ha^{-1} significantly increased the cotton equivalent yield by 26 per cent as compared to the application of recommended fertilizer dose (Jagvirsingh *et al.,* 2004).

A long term field experiment conducted at dry land farming research station, Bhilwara, Rajasthan revealed that the application of 100 per cent recommended N through FYM to maize in rainy season and 100 per cent N and P_2O_5 through fertilizer in the winter season to mustard recorded the maximum plant height and test weight in both the crops and mustard equivalent yield (Kumpawat, 2004).

A field experiment was conducted to study the effect of organic and inorganic nutrient sources on growth, yield and uptake of nutrients by tomato on a calcareous Vertisol. The treatment combinations involving half RDF *i.e.* 50:25:12.5 $N:P_2O_5:K_2O$ kg ha^{-1} + half RDF through FYM + cowdung urine slurry recorded the highest dry matter yield at 105 days after planting and also fruit yield of 1892.00 g plant-1 over control. (Poul *et al.,* 2004).

Sabale (2005) reported that nitrogen supplied through FYM in soybean resulted in higher number of pods per plant, seeds per pod, test weight and yield as compared to other sources of nitrogen.

Varalakshmi *et al*. (2005) recorded significantly higher pod (1.25 t ha^{-1}) and haulm yield (2.78 t ha^{-1}) of groundnut and grain (4.13 t ha^{-1}) and straw (9.53 t ha^{-1}) yield of finger millet with the package of practices (RDF + FYM) when compared to 100 per cent N supply through FYM application in groundnut + finger millet cropping system.

Balyan *et al.* (2006) conducted an experiment to study the effect of integrated nutrient management on maize during *kharif* 2001 and 2002 in a sandy clay loam soil at Dryland Farming Research Station, Bhilwara which revealed that application of FYM @ 10 t ha^{-1} significantly increased final plant height (10.26 per cent) and dry matter accumulation per plant (18.36 per cent) which ultimately enhanced uptake of N, P and K by the crop and was 36.32, 39.32 and 26.01 per cent increase than no FYM on mean value basis over application of 100 per cent RDF. On mean value basis, the application of 100 per cent RDF increased plant height (8.17 per cent), dry matter accumulation plant $^{-1}$ (12.90 per cent).

Application of farmyard manure at 7.5 t ha^{-1} resulted in significantly higher number of pods per plant (18.42), kernels per pod (1.71), shelling per cent (65.83), pod yield (22.51 q ha^{-1}) and oil content (45.65 per cent) (Dutta and Mandal, 2006).

Ghuman and Sur (2006) conducted an experiment to study the effect of manuring on soil properties and yield of rainfed wheat during 1994-2000 in a loamy sand soil at the Research Farm of Punjab Agricultural University, Ludhiana. Application of FYM @ 18 t ha^{-1} (3434.00 kg ha^{-1}) recorded significantly more yield by 10.70 per cent than FYM @ 6 t ha^{-1} (3156 kg ha^{-1}) during first year of investigation..

Application of different organic nitrogen sources significantly influenced the tomato growth and yield. Among the different organic sources, substitution of 100 per cent N as FYM recorded plant height, number of branches per plant and yield comparable to that of 100 per cent per cent N as urea (Kannan *et al.,* 2006).

Kler and Walia (2006) opined that the treatment supplemented with FYM along with crop residue incorporation and green manuring recorded higher growth components *viz.,* dry matter accumulation and leaf area index over chemical farming in wheat under maize-wheat cropping system and it also proved beneficial in boosting up the crop yields by 12.40 per cent compared to chemical fertilizers.

Madhuri *et al.* (2006) conducted studies on the effect of organic manure and biofertilizers on growth and yield of turmeric at the College of Agriculture, Nagpur during 2003- 2004. Application of $N:P_2O_5:K_2O$ @ 120:60:60 kg ha^{-1} recorded higher plant height, number of leaves, size and surface area of leaves, girth of pseudostem, number of tillers plant-1 and fresh yield (t ha^{-1}) of turmeric over FYM applied @ 10 t ha^{-1} in combination with bio-fertilizer.

Santoshkumar and Shashidhara (2006) conducted a field experiment to study the effect of integrated nutrient management in chilli genotypes at Main Agricultural Research Station, Dharwad, during *kharif* 2002 under rainfed conditions on a medium black soil. Application of organics *viz.,* FYM @ 10 t ha^{-1} along with 100 per cent RDF resulted in higher fruit yield (813 kg ha^{-1}) over 100 per cent RDF (kg ha^{-1}) followed by the combined application of FYM @ 5 t ha^{-1} + chilli stalk @ 5 t ha^{-1} along with 100 per cent RDF + secondary and micronutrients + bio-fertilizers (727 kg ha^{-1}) with the genotype byadagi dabbi.

Sable *et al.* (2007) conducted studies on tomato var. Parbhani Yashshri at MAU, Parbhani during 2002-03 to study the effect of organic sources of nutrients on growth and yield of tomato on a slightly alkaline soil. Results revealed that organic mode of plant nutrition through various combinations of neemcake and vermicompost was found superior to chemical fertilizers alone. A higher number of branches and fruit yield with the combination of 50 per cent N through neem cake and 50 per cent N through vermicompost were recorded.

Mohd. *et al.* (2007) conducted an experiment to study the effect of integrated use of FYM and fertilizer nitrogen with and without sulphur on yield and quality of Indian mustard (*Brassica juncea* L.) during winter 2000-2001 in the saline alkali belt of Indo-Gangetic alluvium of Eastern Uttar Pradesh. Results revealed that application of 75 per cent N through FYM + 25 per cent N through fertilizer + 40 kg S ha^{-1} recorded significantly lower seed yield (1.00 t ha^{-1}) and stover yield (4.28 t ha^{-1}) over 25 per cent N through FYM + 75 per cent N through fertilizer + 40 kg S ha^{-1} besides recording lower uptake of N, P and K by mustard.

Panwar and Munda (2007) obtained higher pod yield (3.16 t ha^{-1}) with the application of 10 t ha^{-1} farmyard manure or pig manure and it was comparable to recommended dose of fertilizer. Pod, protein and oil yield were significantly higher with 10 t ha^{-1} farmyard manure applied in addition to 50 and 75 per cent recommended dose of NPK.

Borse *et al*. (2008) reported that application of FYM at 10 t ha^{-1} significantly increased the growth and yield attributes of groundnut *viz*., number of branches per plant, plant spread, number of root nodules per plant, pod and haulm yields, test weight, shelling percentage, protein content, protein yield, oil content and oil yield

Muneshwar Singh *et al*. (2008) observed that among all four nutrient supplying system, the seed yield of soybean (3.86 and 3.88 t ha^{-1} in FYM and poultry manure, respectively) was at par with in a year which suggests that soybean can be grown by using the organic sources of nutrient alone without any loss in yield.

Anil Kumar *et al.*(2009) revealed that the maximum grain yield of lentil (1175 kg ha^{-1}) was with the application of 5 t FYM ha^{-1} as compared to without application of FYM (905 kg ha^{-1}).

Kedino Zango Kanaujia *et al.* (2009) reported that the application of FYM at 60 t ha^{-1} recorded significantly taller plants (29.45 cm), stalk length (7.77 cm), head diameter (12.91 cm), head size (237.39 cm^2), head compactness (135.65), net head weight (1263 g), net head yield (467.62 q ha^{-1}) and vitamin C content (143.19 mg 100 mg^{-1}) of cabbage. FYM at 60 t ha^{-1} also gave the highest net return (Rs 1, 59, 810 ha^{-1}) in cabbage.

Sharma and Thomas (2010) reported that the significantly higher seed yield of blackgram (17.4 q ha^{-1}) with application of 10 t ha^{-1} farmyard manure as compared to control (no farmyard manure application). This was attributed to increase in number of pods per plant, seeds per pod and seed yield by 20, 12 and 7 per cent, respectively over control.

Dadgale *et al.* (2011) revealed that the growth and yield of greengram was significantly higher with the application of RDF as compared to application of FYM and vermicompost equivalent to RDN.

Jat *et al.* (2011) reported that the significantly higher pod yield and groundnut equivalent yield (1,037 kg ha^{-1} & 2,187 kg ha^{-1}, respectively) with the application of FYM @ 5 t ha^{-1} in groundnut-wheat cropping system over RDF (939 kg ha^{-1} and 1948 kg ha^{-1}, respectively).

Bachhav *et al.* (2012) revealed that an application of FYM @ 5 t ha^{-1} recorded maximum plant height (99.69cm).

Guriqbal Singh *et al*. (2012) noticed that application of 5 t FYM ha^{-1} improved chickpea grain yield by 14.89 per cent over no application of FYM. It improved the plant growth parameters *viz*., plant height (54.1 cm), branches $plant^{-1}$ (7.92) and yield attributes *viz*., number of pods (48.2 $plant^{-1}$) and 100-seed weight (13.5 g).

Ramesh *et al*. (2012) observed that the 100 per cent organic nutrient management through well composted cattle dung manure which could supply 30 kg N ha^{-1} resulted in significantly lower seed yield of soybean which was 7.8 per cent less than 100 per cent inorganic nutrient management. In the second year, the yield reduction was 5.3 per cent and in subsequent third year, the yields under organic management were found superior over inorganic management.

Vishwakarma *et al*. (2012) reported that the highest pod and kernel yields with application of FYM at 10 t ha^{-1} which was statistically at par with other nutrient sources. Maximum shelling percentage and test weight were with treatment comprised of vermicompost.

Rahevar, H.D., *et al.* (2015) conducted experiement to study the effect of soil application of FYM with combination of Fe and Zn with recommended dose of N (25 kg ha^{-1}) and P (50 kg ha^{-1}) on growth, yield and quality by groundnut. Application of FYM

@ 5 t ha^{-1} with 5 kg Fe ha^{-1} + 4 kg Zn ha^{-1} to groundnut considerably increased yield, yield attributes and quality parameters.

Rajesh Kumar *et al.* (2015) conducted the experiement to study the effect of nutrient supplementation through organic sources on growth, yield and quality of coriander during 2011-2012. Among different treatments, the maximum plant height, number of primary and secondary branches, number of umbels/plant, number of umbelets/umbel, number of seeds/ umbel, weight of 1000 seeds and seed yield (14.58 q/ha) were recorded with the application of better combination of organic sources in the treatment of Application of FYM 25 % (5 t ha^{-1}) + Vermi-compost 75 % (3.75 t ha^{-1}).

2.2.2 Effect of Vermicompost on growth and yield crops.

Highest dry matter and seed yield of greengram in a pot culture experiment was recorded with the application of 75 per cent RDN as urea along with 5 t per ha vermicompost (14.7 and 13.8 g $plot^{-1}$, respectively) and it was at par with the 100 per cent application of N as vermicompost equivalent to RDN. Further, similar trend was also noticed in root weight and nodule dry weight with 75 per cent N as urea with 5 t ha^{-1} vermicompost application (Rajkhowa *et al*., 2000).

Significantly higher grain yield (21.72 q ha^{-1}) and husk yield (32.61 q ha^{-1}) of soybean, when vermicompost was applied at 2 t ha^{-1} when compared to control (17.22 and 27.96 q ha^{-1}) while it remained on par with poultry manure application at 2 t ha^{-1}, which recorded a grain yield of 21.44 q ha^{-1} and a husk yield of 32.30 q ha^{-1} (Samad, 2001).

Govindan and Thirumurugan (2002) revealed that in soybean application of vermicompost equivalent to 100 per cent RDN and 75 per cent RDN were able to maintain yield levels comparable to that of 100 per cent NPK through inorganic fertilizer. Whereas, pressmud equivalent to 100 per cent N and 75 per cent N and composted coir pith (100% N and 75% N) were not able to maintain the yield level.

Bhalerao *et al*. (2003) reported that the application of 3 t of vermicompost ha^{-1} had no significant effect on plant height, leaf number, leaf area, leaf area index and harvest index. However, dry matter per plant, cob weight per plant, test weight, grain and fodder yield of maize per hectare were influenced significantly due to application of vermicompost.

Jayaprakash *et al*. (2003) recorded significantly higher grain yield of maize (67.44 q ha^{-1}) with the application of vermicompost @ 2 t ha^{-1} which was on par with the grain yield of maize obtained by the application of FYM@ 10 t ha^{-1} (65.22 q ha^{-1}).

Rajendran *et al*. (2006) reported that the application of vermicompost at 5t ha^{-1} as soil application combined with foliar spray of 3 per cent *panchagavya* 10 days after sowing could be recommended to enhance the yield and quality of grains of *Amaranthus* cv. CO-2.

Shwetha (2007) studied the effect of organic nutrient management practices on soybean-wheat cropping system in northern transitional tract of Dharwad. The results revealed that recommended N supply through vermicompost, compost and vermicompost + compost resulted in on par yields among themselves and also with RDF and RDF + FYM in both soybean and wheat. Further, similar trend was also observed in growth and yield components.

Significantly higher grain yield and protein contents in blackgram seed harvested from the plots treated with vermicompost (Parthasarathi *et al*., 2008).

An investigation carried at Kanpur indicated that application of vermicompost @ 2 t ha^{-1} resulted in higher dry matter (35.57 g $plant^{-1}$), seed weight $plant^{-1}$ (14.05 g) and seed (19.09 q ha^{1}) and straw yields (22.99 q ha^{-1}) of chickpea. The magnitude of increase in chickpea yield with vermicompost was greater when no biofertilizer was applied. Vermicompost along with 60 kg ha^{-1} DAP recorded similar yield as that of 120 kg ha^{-1} (Raghwendra and Kedar, 2008).

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

Navlakhe *et al.* (2009) recorded that the application of two tonnes of vermicompost ha^{-1} resulted in significantly higher values in growth parameters *viz*., plant height (123.00cm), number of leaves $plant^{-1}$ (108.23), leaf area (54.84 dm^2 $plant^{-1}$), dry matter $plant^{-1}$ (45.84 g), leaf area index (0.046) and yield parameters *viz*., number of bolls $plant^{-1}$ (14.75), seed cotton weight (3.01 g $boll^{-1}$), and seed cotton yield $plant^{-1}$ (12.88 g $plant^{-1}$) and seed cotton yield ha^{-1} (8.71 q ha^{-1}). Further, it was also noted that application of vermicompost @ 2 tha^{-1} and FYM application @ 5 t ha^{-1} were found on par with respect to these values.

Niranjan *et al.* (2010) showed that the application of vermicompost had significant positive effects on growth performances and yield of *Vigna radiata* as compared to control.

Significantly higher maize grain yield (45.87 q ha^{-1}), fodder yield (56.93 q ha^{-1}), grain yield $plant^{-1}$ (87.2 g), cob length (17.8 cm) and cob diameter (14.1 cm) and dry matter accumulation (6990.0 kg ha^{-1}) with poultry manure @ 1.0 t ha^{-1} as compared to no-organic manures application and however, it was found on par with vermicompost application @ 2.5 t ha^{-1} (Hulihalli *et al.* (2011).

Sharma *et al.* (2012) reported that the application of 50 per cent N through vermicompost + 50 per cent N through decomposed organic waste recorded significantly higher plant height (178.81 cm), ear head length (20.5 cm), effective tillers m^{-1} (22.78) and grain yield (17.58 q ha^{-1}) and stover yield (57.14 q ha^{-1}) of pearl millet over absolute control. However, this nutrient management practices was found on par with the treatments which received 100 per cent N through vermicompost and composted organic manure alone.

Konthoujam *etal.* (2013) opined that integration of 75% RDF with vermicompost @ 1 t ha^{-1} and PSB produced significantly higher plant height, number of nodules $plant^{-1}$ and dry weight of nodules $plant^{-1}$ of soybean than the other treatments.

Maruthi *et al*. (2014) showed that application of 50% recommended dose of NPK (15:40:18.75 kg ha^{-1}) + 50 % recommended dose of FYM (5 t ha^{-1}) + 50 % Vermicompost (2 t ha^{-1}) + Brady rhizobium (250 g ha^{-1}) + PSB (250 g ha^{-1}) recorded significantly highest seed yield plant^{-1}(10.2 g plant^{-1}) and seed yield ha^{-1} (28.65 q ha^{-1}) as compared to RDF (30:80:37.5 kg ha^{-1}).

Muzafer *et al.,* (2015) showed that survival rate was higher in all treatments than control except at the highest dose of NPK fertilizer in which the survival rate was found minimum (74.38 %) and also the root length and seedling height was maximum at the optimum dose of Vermicompost (20 %) treated plants and was found minimum in the highest dose (300 g) of NPK fertilizer.

2.2.3 Effect of Jeevamrutha on crop growth and yield crops.

Vasanthkumar (2006) opined that jeevamrutha was a fermented liquid product rather than source of nutrients containing huge quantity of microbial load and which enhances soil bio-mass upon its application to soil even at very lesser rate as it act as a tonic to soil besides improving soil health.

Manjunath *et al*. (2009) reported that FYM @ 7.5 t ha^{-1} + jeevamrutha @ 500 l ha^{-1} recorded on par values of yield and yield attributes with FYM @ 7.5 t ha^{-1} + 100 per cent RDF but it has given significantly higher net returns.

Adil and Sukhraj (2010) recorded the stem circumference observed was maximum for okra plants treated with chemical fertilizers (3.77 cm), followed by vermicompost (3.17 cm), vermiwash + vermicompost (3.10 cm) and cattle dung (2.50 cm). The marketable yield of the fruits per plant in chemical fertilizers (75.43 g) was maximum followed by vermiwash + vermicompost (69.11 g), vermicompost (59.04 g) and cattle dung (31.63 g).

Nileema S. Gore and M. N. Sreenivasa (2011) conducted experiement to study the influence of liquid organic manures *viz.,* panchagavya, jeevamruth and beejamruth on the growth, nutrient content and yield of tomato in *kharif* 2009 at Main Agricultural Research Station, University of Agricultural Sciences, Dharwad. In this study, significantly highest plant growth and root length was recorded with the application of RDF + Beejamruth + Jeevamruth + Panchagavya and it was found to be significantly superior over other treatments.

2.3 Effect of organic manures on soil microbial biomass and dehydrogenase activity.

2.3.1 Soil microbial biomass

Soil micro-organisms play a very important role in soil fertility not only because of their ability to carry out bio-chemical transformation but also due to their importance as a source and sink for mineral nutrients. Use of organic manures is the object to accelerate microbial processes to enhance availability of nutrients in the assimiable form. The microbial activities are enhanced as the fresh organic material acts as the nutrient source for the diverse soil flora and fauna. Organics modify the micro-climate, alter the environment of soil microbes, enhance soil flora and fauna activity, modify soil moisture regimes and properties associated with it and soil temperature in the root zone. Microbial biomass is the total sum of all micro-organisms present in soil.

Amongst microbes, bacterial population was highest as compared to fungal and actinomycetes at all crop growth stages. Microbial count increased after 30 days of sowing and reduced substantially at harvest time. Highest fungal count was recorded with that of 100 per cent N alone, whereas population of bacteria and actinomycetes was favoured by application of 100 per cent N, P_2O_5, K_2O + FYM and FYM alone (Rita and Varde, 1998).

Organic manures not only supplies a higher amount of different nutrient elements but also contains beneficial microbes like nitrogen fixing bacteria, mycorrhizae and growth promoting substances for betterment of crops (Barik *et al*., 2006).

Sreenivasa (2007) observed that the higher soil biological properties in treatments receiving 50 per cent organic + 50 per cent inorganic manures *viz*., bacteria (118 X 10^7 cfu g^{-1} of soil), fungi (86 X 10^4 cfu g^{-1} of soil), actinomycetes (68 X 10^6 cfu g^{-1} of soil), free living nitrogen fixers (52 X 10^3 cfu g^{-1} of soil) and PSB (42 X 10^3 cfu g^{-1} of soil) over 75 per cent organic manure application.

Deshpande *et al.* (2010) observed that application of organic manures (FYM, poultry manure, vermicompost and green manure) played an important role in enhancing microbial population *viz.,* bacteria (9.5 X 10^7 cfu g^{-1} of dry soil), fungi (5.98 X 10^4 cfu g^{-1} of dry soil) and actinomycetes (2.30 X 10^6 cfu g^{-1} of dry soil) at harvest of the rice crop.

Harish *et al.* (2010) at TNAU, Coimbatore found that incorporation of green manure in rice field recorded significantly higher bacterial load (11.0, 12.6, 13.6 and 5.3 x 10^6 cfu g^{-1} soil at active tillering, panicle initiation, flowering and harvest stages, respectively), fungi population (3.4, 4.1, 5.6 and 6.0 x 104 cfu g^{-1} soil) and actinomycetes population (1.8, 3.0, 2.6 and 2.2 x 104 cfu g^{-1} soil).

Application of poultry manure at 150 per cent recommended nitrogen dose lead into higher counts of bacteria (82.4 x 103 cfu g^{-1} soil), fungi (37.8 x 10^3 cfu g^{-1} soil) and actinomycetes (58.2 x 10^3 cfu g^{-1} soil) (Meena *et al.*, 2010).

Reddy *et al.* (2010) observed that population of total bacteria (63.6 x 10^6 cfu g^{-1} soil), fungi (34 x 10^4 cfu g^{-1} soil) and actinomycetes (53.7 x 10^4 cfu g^{-1} soil), were maximum with FYM 12.5 t ha^{-1} + cattle urine (equivalent to 125 kg N ha^{-1}) and minimum of the same was found with recommended practice (FYM 10 t +100:50:50 kg NPK ha^{-1}) at Kathalagere.

In maize-chickpea cropping system, it was observed that higher microbial load in panchagavya *viz*., bacteria (26.1 cfu ml^{-1}), fungi (18 cfu ml^{-1}) and PSB (5.70 cfu ml^{-1}), free living nitrogen fixers (5 cfu ml^{-1}) and actinomycetes (4.20 cfu ml^{-1}) (Anon., 2011).

Dhok and Ghodpage (2011) recorded increased population of bacteria (9.25 X 10^8 cfu g^{-1} of soil), fungi (6.00 X 10^4 cfu g^{-1} of soil) and actinomycetes (8.75 X 10^6 cfu g^{-1} of soil) in soybean–gram cropping system under integrated module *viz.,* application of biofertilizer, FYM (5 t ha^{-1}), vermicompost (2.5 t ha^{-1}) and 50 per cent RDF (12.5:25:0) and weed control through pre-emergence herbicide + hand weeding.

Sharada (2013) reported that higher population of soil microflora *viz.,* bacteria, fungi, actinomycetes, free living nitrogen fixers and PSB at different growth stages of both greengram and *rabi* sorghum with combined application of organic manures along with panchagavya spray as compare to RDF.

2.3.2 Dehydrogenase activity

The dehydrogenase activity indicate the enhanced microbial activity of soil and serve as an index of microbial biomass. Application of organic matter @ 10 t ha^{-1} significantly increased the dehydrogenase activity of soils (0.54 µg TPF /g/hr) compared to 5 t ha^{-1} of organic matter (0.46 µg TPF /g /hr) and control (0.38 µg TPF /g /hr) (Ramamurthy et al., 1995).

The higher dehydrogenase, activity were recorded with the substitution of 100 per cent RDN with vermicompost, poultry manure, bio-gas slurry and FYM and were at par with 50 and 100 per cent substitution. (Gopal Reddy., 1997).

At Indian Grassland and Fodder Research Institute, Jhansi, research was conducted with various Jaivic and vedic krishi inputs such as Angara, Amritpani, Panchagavya and Gomuthra etc. The results revealed that all the jaivic and vedic krishi inputs improved the soil microbial population and soil biological activity (Sadanandan and Drand, 2005).

Manjunatha (2006) observed a marked increase in dehydrogenase activity in soils of organic farms than conventional farms in the selected major cropping systems viz., cotton, sugarcane, jowar and vine yard.

Shwetha and Babalad (2008) reported that the dehydrogenase activity was higher with combined application of organics and fermented organics than their individual applications and RDF + FYM. The highest dehydrogenase activity of 34.84 µg TPF g^{-1} soil day^{-1} was observed with compost + vermicompost + green leaf manure + Jeevamrut + Beejamrut and was on par with the treatment receiving vermicompost + green leaf manure + Jeevamrut + Beejamrut + Panchagavya. The lowest dehydrogenase activity of 24.27 µg TPF g^{-1} soil day^{-1} was noticed with the application of RDF + FYM at 60 DAS of soybean in soybean-wheat cropping system.

Saha *et al*. (2011) examined on effect of elevated CO_2 on dehydrogenase activity in rhizosphere soil and reported that the significant increase in soil dehydrogenase activity in pigeon pea, grown under enriched CO_2 environment.

Trilok and Janardan (2011) reported the influence of inorganic and organic nutrient sources on soil enzyme activities at Banaras Hindu University, Varanasi. The results revealed that dehydrogenase activity improved from 43.8 in control to 46.5 in inorganic (T2), 46.8 to 50.4 in combined, and 50.6 to 53.3 in organic treatments at zero day of incubation. Significantly higher values of dehydrogenase activity over control were obtained in case of organic treatments where maximum 53.3 µg TPF produced g^{-1} soil.

Manna *et al*. (2013) studied the effect of elevated CO_2 on bulk soil and reported that higher level of CO_2 enhanced the activity of dehydrogenase activity in rice.

2.4 Effect of organics on the availability and nutrient uptake

Vadivel *et al.* (1999) reported that application of enriched FYM treatment recorded significantly higher NPK uptake when compared to no application of organic sources. Well developed root system and sustained availability of applied nutrients through enriched FYM might be the reason for higher NPK uptake.

Rajkhowa *et al.* (2000) observed that application of vermicompost showed significant positive effect on nutrient content obtained with the application of 75 per cent N through urea + 5 t ha^{-1} vermicompost over control. Increase in the doses of vermicompost from 2.5 to 5.0 t ha^{-1} also significantly increased the plant nutrients. The highest N, P and K contents was recorded in plant were from 1.23 to 1.54, 0.37 to 0.47 and 0.82 to 1.05 per cent, respectively.

Prakash *et al*. (2002) observed that availability of all nutrients were significantly higher in organically treated plots compared to chemically treated plot and untreated control plot. The values of NPK availability due to FYM treatment were higher over all commercial manures but these were significantly higher only with respect to phosphorus availability.

Bhalerao *et al*. (2003) reported that the highest protein content, protein yield, N, P and K uptake was recorded after harvest of sorghum with 100 per cent RDF and 3.0 t vermicompost ha^{-1}.

Hangarge *et al.* (2004) reported that the application of liquid organic cowdung urine slurry @ 2 lit m^{-2} along with vermicompost @ 5 t ha^{-1} resulted in higher available N (353.00 kg ha^{-1}), P_2O_5 (21.00 kg ha^{-1}) and K_2O (284.00 kg ha^{-1}) after harvest of chilli than RDF (319.00, 18.00, 280.00 kg N, P_2O_5 and K_2O, respectively).

Vasanthi and Subramanian (2004) observed that the highest crude protein N, P and K concentration and uptake were recorded in the treatment that received vermicompost @ 2 t ha^{-1} along with 100 per cent recommended levels of N, P and K.

Chaturvedi and Chandel (2005) reported that highest total uptake of N, P, and K was obtained with recommended NPK + FYM @ 10 t ha^{-1} than recommended NPK alone in soybean.

Dadgale *et al*. (2011) observed that significantly higher nutrient content *viz*., nitrogen (51.59 kg ha^{-1}), phosphorus (27.20 kg ha^{-1}) and potassium (33.13 kg ha^{-1}) of greengram was in the treatment supplied with RDF and it was followed by RDN through soybean straw compost (46.37, 24.24 and 30.47 kg ha^{-1}, respectively) over control.

Pradeep Gopakkali *et al*. (2011) revealed that the nutrient uptake of nitrogen (107.6 kg ha^{-1}), phosphorus (26 kg ha^{-1}) and potassium (78.7 kg ha^{-1}) was significantly higher with application of FYM @ 10 t ha^{-1} along with cow urine equivalent to 100 kg N ha^{-1}.

Partha, *et al*. (2011) combined application of VC 2.5 t ha^{-1} + PC 2.5 + PM 2.5 t ha^{-1} + NC 2.5 t ha^{-1} brought about significant improvement in in N, P and K uptake by groundnut to the extent of 46.44, 41.38 and 15.74% respectively over the 100 % RDF.

Bachhva *et al.* (2012) reported that application of FYM @ 5 t ha^{-1} recorded increase organic carbon (0.307%), available P_2O_5 (55.49 kg ha^{-1}) and available K_2O (245.38 kg ha^{-1}) than rest of the treatments.

Jat *et al.* (2012) indicated that the saturated hydraulic conductivity, total porosity, moisture retention at 1/3 and 15 bar significantly increased but bulk density of soil was decrease significantly with increasing levels of FYM up to 10 t ha^{-1} at harvest of the mustard crop.

Chesti *et al.* (2013) reported that application of 100 % NPK fertilizer with 10 t FYM ha^{-1} significantly increased OC and available N, P, K content of the soil at harvest of wheat crop as compared to inorganic fertilizer alone.

Hussain *et al.* (2013) conducted thatcombined application of inoculation and sulphur (30 kg ha^{-1}) resulted in significant increase the Nitrogen uptake and fixation increased from 180 to 271 and from 83 to 143 kg ha^{-1} in the treatment of inoculation + 30 kg S ha^{-1}.

Dos passes *et al.* (2014) reported that most effective dose combination application is 5.5 Mg ha^{-1} of organic amendments associated with 200 $kgha^{-1}$ of mineral fertilizer to provide optimum yield. The use of organic amendments, rich in nutrients, is a technology to sustainably increase the soybean grain yield

Mona *et al.* (2014) showed that highest seed yield and oil yield was observed from application of 10 t vermicompost with 1699 kg ha^{-1} and 210.9 kg ha^{-1} respectively so application of bacteria had highest harvest index this positive effect was attributed to highest seed yield, in continuance highest protein content was observed from application of bacteria with 32 *per cent*.

Yagoub *et al.* (2015) showed that chicken manure and nitrogen fertilizers were significantly increased the number of seeds pod^{-1} as compared to the control. There was no significant difference among fertilizers treatments on pods weight $plant^{-1}$, number of seeds $plant^{-1}$, 100 seeds weight, seeds production and harvest index %.

Patil and Udmele (2016) reported that total uptake of nitrogen, phosphorus and potassium by soybean was significantly higher due to application of FYM + vermicomopst (50 % each) + Jeevamrut 2 times (30 and 45 DAS) to soybean.

2.5 Effect of organics on economics

Organic farming is initially a soil building process. Organic farming systems ensures in- built capacity to maintain and increase soil health and fertility leading to sustained increase in yield and production and low variability of crops. This resulted in a stabilization of yield, increase in income and sustainability in agriculture. The farm wastes and local organic wastes can be used as inputs for crop production. Manuring can also avoid the use of external inputs as in the conventional farming.

Application of farmyard manure @ 10 t ha^{-1} + 100 per cent recommended dose of fertilizer resulted in higher pod yield of groundnut and higher net returns and B:C ratio (Madhiyazhagan *et al.*, 2001).

Under rainfed conditions higher seed cotton yield and net returns could be achieved with the application 5 t ha^{-1} of farm yard manure or poultry manure (Hulihalli and Patil, 2005).

Solanki *et al.* (2006) reported that the significantly higher pod yield (2785 kg ha^{-1}) of groundnut and gross return of Rs 31447 ha^{-1} with the application of FYM at 10 t ha^{-1}.

Pandey *et al*. (2006) reported that irrespective of application rates, FYM and poultry manure noticed marked increase in the net returns and benefit: cost ratio from garden pea cultivation. FYM @ 20 t ha^{-1} gave the highest net returns (Rs.74202 ha^{-1}) followed by 15 t ha^{-1} (Rs.70718 ha^{-1}).

Madhuri *et al.* (2006) observed higher B: C ratio (1:2.17) with RDF in tomato over FYM @ 10 t ha^{-1} (1:1.95).

In Maize-chickpea cropping system, net returns (Rs. 90648 ha^{-1}) and higher B: C ratio (7.21) in the treatment receiving enriched compost + vermicompost + Green leaf manure + panchagavya spray + biodynamic spray and this was followed by application of enriched compost + vermicompost + Green leaf manure + panchagavya spray (Rs. 84090 ha^{-1} and 6.35, respectively) when compared to control (Rs. 54518 ha^{-1}) (Anon, 2011).

Patil *et al.* (2011) revealed that combination of compost @ 5 t ha^{-1} with 150 kg rock phosphate resulted in higher B:C ratio (3.37).

Jayaram Reddy and Reddy (2011) observed that the higher net returns (Rs 6,730 ha^{-1}) and BC ratio (1.5) with the use of organic manures in field bean cultivar HA-4 as compared to fertilizer use.

The application of 100 per cent RDN through vermicompost, FYM and compost along with jeevamrutha found beneficial in increasing economic returns (Rs 78501 ha^{-1}, Rs 69588 ha^{-1} and Rs 71369 ha^{-1}, respectively) and B:C (2.61, 2.82 and 2.82, respectively) of soybean wheat cropping sequence under irrigated condition (Deshmukh *et al*., 2012).

Channagouda *et al*. (2015) reported that combined application of crop residue (50 %) + vermi compost (50%) equivalent to RDN with lucerne with jeevamrutha at 500 L ha^{-1} surface application recorded significantly higher net returns (Rs 60,009 ha^{-1}) over other combinations.

III. MATERIAL AND METHODS

A field experiment on the effect of "Nutrient management in chickpea (*Cicer arietinum* L.) in black soil under rainfed situation" was conducted during *rabi* season, 2016-17 at Krishi Vignana Kendra farm, Kalaburagi. The details of material used and experimentation methods followed during the course of investigation are presented in this chapter.

3.1 Experimental site

The experiment was conducted at Krishi Vignana Kendra, Kalaburagi in Plot No. C-6 during *rabi* season, 2016-17. Kalaburagi is situated in the North Eastern Dry Zone (Zone-2) of Karnataka between 17º 34' N latitude and 76º 79' E longitude with an altitude of 478 meters above the mean sea level.

3.2 Soil characteristics of experimental site

The soil of the experimental site was shallow to medium black soil. Composite soil sampling was made in the experimental area before the imposition of treatments and was analyzed for chemical and biological characteristics of soil. The values obtained along with the methods employed for their estimation are presented in Table 1.

3.3 Climatic conditions

The Krishi Vignana Kendra, Kalaburagi is situated in North Eastern Dry Zone (Zone 2) of Karnataka state. The mean monthly meteorological data of rainfall, temperature and relative humidity during the period of experimentation (2016-17) and mean of last 16 years (2000 – 2016) were recorded at the meteorological observatory of the ARS, Kalaburagi are presented in Table 2.

3.4 Experimental details

The details of the experiment are given below.

3.4.1 Treatment details

Table 1: Physico-chemical and biological properties of soil of the experimental site.

Particulars	Value obtained
I. Physical properties	
1. Sand (%)	50.00
2. Silt (%)	23.75
3. Clay (%)	26.25
4. Textural	Clay Loam
II. Chemical properties	
1. Soil pH (1:2.5)	8.20
2. Electrical conductivity (dSm^{-1})	0.32
3. Organic carbon (%)	0.47
4. Available Nitrogen (kg ha^{-1})	314
5. Available Phosphorus (P_2O_5) (kg ha^{-1})	37
6. Available Potassium (K_2O) (kg ha^{-1})	643
7. Available Sulpur (SO_4) (kg ha^{-1})	13
III. Available Micronutrients	
1. Zinc (ppm)	0.92
2. Iron (ppm)	8.68
3. Copper (ppm)	2.80
4. Manganese (ppm)	11.24
5. Boron (ppm)	0.36
IV. Soil Microbial Biomass	
1. Bacterial (No. X 10^7 cfu g^{-1} of soil)	15.45
2. Fungi (No. X 10^5 cfu g^{-1} of soil)	26.83
3. Actinomycetes (No. X 10^3 cfu g^{-1} of soil)	10.58
4. Dehydrogenase activity (µg TPF h^{-1} g^{-1} soil)	16.73

Table 2: Mean monthly meteorological data for the year 2016 - 17 and average of the last 16 years (2000 -16) as recorded at Agricultural Research Station, Kalaburagi

Month	Rainfall (mm)		Temperature (°C) Mean maximum		Temperature (°C) Mean minimum		Relative humidity (%)	
	2016-17	2000-2016	2016-17	2000-2016	2016-17	2000-2016	2016-17	2000-2016
January	0.00	5.00	29.80	33.40	16.80	22.30	49.90	82.00
February	0.00	3.40	33.60	35.20	22.80	20.50	43.20	79.00
March	30.20	7.10	36.20	31.60	26.10	19.10	42.50	79.00
April	20.60	20.20	39.50	33.10	30.10	16.20	36.20	76.00
May	43.80	12.50	37.90	30.50	29.00	16.80	54.90	77.00
June	182.30	42.80	31.00	32.30	25.10	18.50	82.80	62.00
July	209.70	126.20	28.90	29.30	24.30	22.60	86.40	56.00
August	38.20	68.40	30.20	30.20	24.60	24.40	82.90	53.00
September	298.00	75.20	28.30	31.90	23.50	25.30	88.70	60.00
October	30.40	180.7	29.90	34.80	23.00	23.30	72.80	79.00
November	16.10	63.80	30.20	36.90	17.50	22.60	67.60	77.00
December	08.40	24.10	29.50	38.60	19.30	22.50	63.50	80.00
Total	877.70	630.40						

The experiment consisted of eleven treatments comprising of organic manure alone and with liquid organic manures and a control with chemical fertilizers (RDF). The plan of experimental layout is shown in Fig 2.

3.4.2 Plot size:

Gross plot: 3.6 m x 3.0 m

Net plot : 3.0 m x 2.8 m

3.4.3 Spacing

Inter row : 30 cm

Intra row : 10 cm

Treatments :

T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2 : FYM @ 5 t ha^{-1} + 50% RDF

T_3 : FYM @ 5 t ha^{-1} + 75% RDF

T_4 : FYM @ 5 t ha^{-1} + 100% RDF

T_5 : FYM @ 5t ha^{-1} + Jeevamrutha

T_6 : VC @ 2.5 t ha^{-1} + 50% RDF

T_7 : VC@ 2.5 t ha^{-1} + 75% RDF

T_8 : VC@ 2.5 t ha^{-1} + 100% RDF

T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha

T_{10} : RDF(10:25:0) + Jeevamrutha

T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

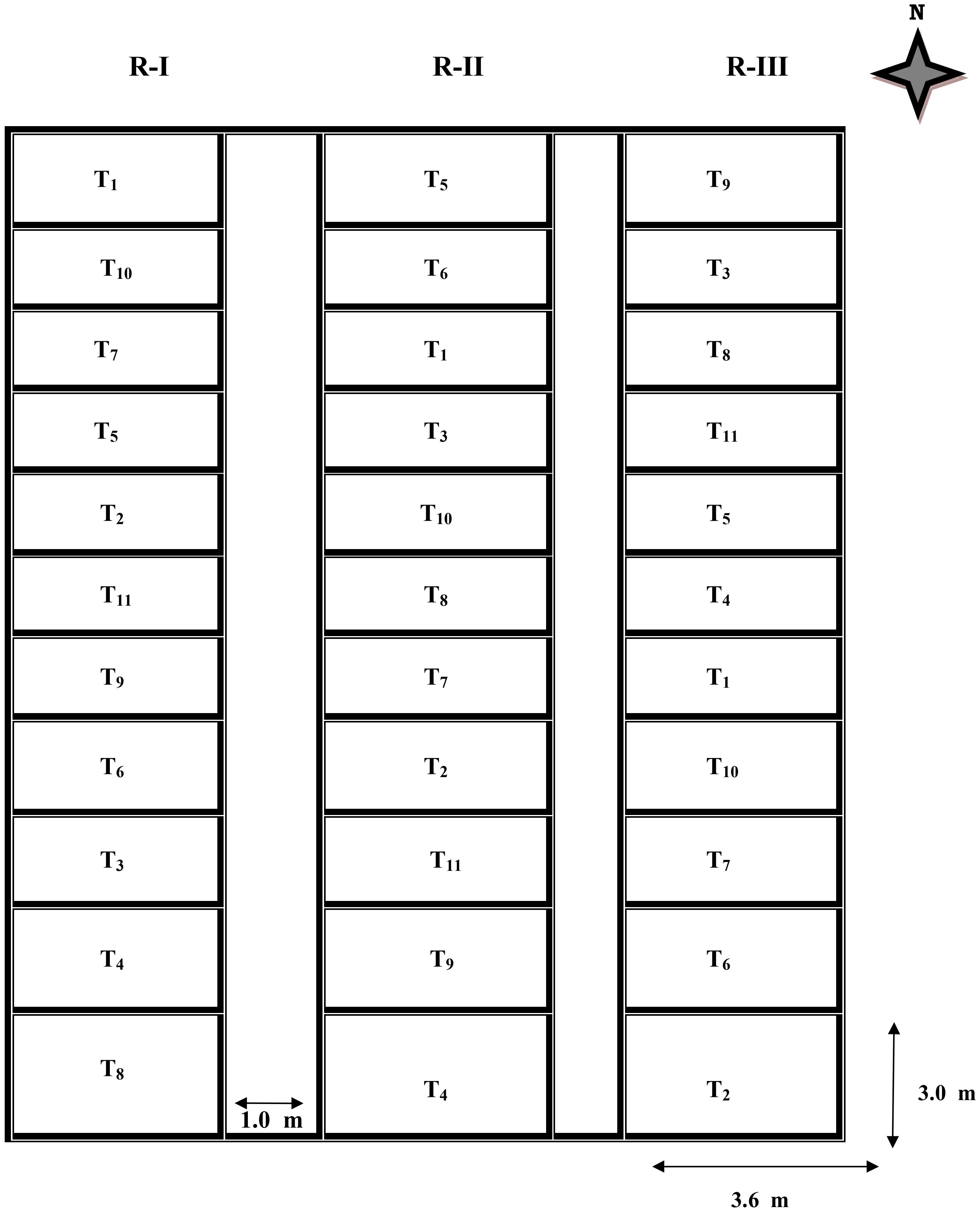

Fig 2. Plan of experimental layout

Note: Zinc Sulphate 15 kg ha^{-1}, Borax @ 5 kg ha^{-1}, and Calcium Sulphate @125 kg ha^{-1} are common for all the treatments.

RDF: Recommended dose of fertilizers, **FYM**: Farm Yard Mannure,

VC: Vermicompost, **LF**: Liquid Fertilizer.

3.4.4 Design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications.

3.4.5 Previous crops grown

During the previous years, *Pigeon Pea* crop was cultivated in the experimental location between the years 2015-2016.

3.5 Cultural operations

3.5.1 Land preparation

The land was ploughed with tractor after the harvest of the *Pigeon pea* and harrowed twice to crush the clods. Stubbles and weeds were removed from the experimental area and the soil was brought to fine tilth. The experimental site was applied with FYM @ 5.0 t ha^{-1}, and VC@ 2.5 t ha^{-1} in the fourth week of October 2016. Jeevamrutha at the time of sowing. The experimental layout was done as per the plan.

3.5.2 Procedure for preparation of fermented liquid fertilizer (Jeevamrutha)

Ingredients:	Cow dung	:	10 kg
	Cow urine	:	10 *l*
	Jaggery	:	2 kg
	Soil	:	1 kg
	Legume flour	:	2 kg

The above ingredients were taken in a 200 litres capacity drum and the volume was made up to 200 litres with the addition of water. The drum was kept in shade and stirred thrice in a day, and was covered with the lid. After a week, the jeevamrutha was ready and was used for soil application.

3.5.3 Organic manure incorporation

Organic manures such as farmyard manure and vermicompost were calculated as per the requirements based on the nutrients contents and incorporated into the soil two weeks before sowing and just before sowing in case of vermicompost. The recommended dose of phosphorus was balanced with the application of urea and DAP. These organic manures were analysed for NPKS contents and mentioned in the Appendix-III. Jeevamrutha was applied to soil at the rate of 200 litres per hectare at the time of sowing in treatments from T_5, T_9 , T_{10} , and T_{11}.

3.5.4 Seeds and sowing

Certified seeds of chickpea (JG-11) were procured from the Seed Unit of ARS, Kalaburagi. The seeds were soaked overnight and shade dried for an hour then treated with *Trichoderma* @ 10 g kg^{-1} followed by *Rhizobium* @ 20 g kg^{-1} before sowing. The seeds were sown on 23-10-2016 by hand dibbling at 30 cm x 10 cm spacing.

3.5.5 Fertilizer application:

At the time of sowing recommended dose of fertilizer 10:25:0 kg N: P_2O_5: K_2O ha^{-1} was applied. Nitrogen and phosphorous applied in the form of diamonium phosphate (DAP) to RDF treatments. While, as per package, chickpea did not receive any FYM, vermicompost and jeevamrutha.

3.5.6 After care of Chickpea

A week after emergence, the optimum plant population was maintained by taking up gap filling and thinning the crop. Interculturing operations (hoeing) were carried out twice at 20 and 50 days after sowing (DAS) and one hand weeding was done at 35 DAS. To control insect pests and diseases the crop was sprayed with Quinolphos @ 1 ml l^{-1} and SAAF @ 2g l^{-1} of water, at 30 DAS. To control the infestation of *Helicoverpa* spray the Biosiddi @ 1 ml l^{-1} and Imamectin benzoate @ 0.25 g l^{-1} of water at 45 DAS. and chemical sprays of Biosiddi @ 2 ml l^{-1} and SAAF @ 2 g l^{-1} of water at 65 DAS. The crop was given one protective irrigation on 02-12-2016 to avoid moisture stress to the standing crop.

3.5.6.5 Harvesting and threshing

Chickpea crop was harvested at 95 DAS. The plants from net plot were harvested separately, sun dried and threshed. Seeds from individual plots were cleaned, dried and weight was recorded.

3.6 Details of collection of experimental data

3.6.1 Growth parameters of chickpea

Five randomly selected plants in the plot area were tagged and used for making observations on various growth parameters at 30 DAS, 60 DAS and at harvest.

3.6.1.1 Plant height

The height of plant was measured from base of the plant to the tip of shoot from five plants and mean plant height was worked out and expressed in centimeters.

3.6.1.2 Number of secondary branches per plant

The number of branches emerging from primary branches were counted and the average of five plants was expressed as number of secondary branches per plant.

3.6.1.3 Dry matter production and its accumulation

The whole plant samples were dried separately at 65 to 70°C in hot air oven till a constant weight. Completely dried samples were weighed and the dry weight of different plant was expressed in grams per plant.

3.6.1.4 Number of nodules per plant

The number of nodules per plant at 40 and 60 DAS was recorded by carefully uprooting five randomly selected plants in adjacent rows of border lines in each plot and the average of five plants was expressed as a number of nodules per plant. The selected plants were saturated with water on the previous evening of observation. Next morning, selected five plants were carefully lifted along with the adhering soil mass. Enough care was taken to keep the root system intact so that none of the nodules were lost. All the nodules were collected and counted after carefully washing-off the soil.

3.6.2 Yield and yield components

3.6.2.1 Number of pods per plant

Total filled pods present in five tagged plants were counted and the mean was calculated.

3.6.2.2 Test weight

The weight of 100 seeds drawn randomly from seed yield of plot was recorded in grams and expressed as test weight.

3.6.2.3 Seed yield

The dried pods were shelled and seed yield was recorded and expressed as seed yield per net plot and the yield per hectare was computed and expressed in kg ha^{-1}.

3.6.2.4 Stover (bhusa/straw) yield

After shelling the grains from the pods of plants, the left out crop residue was taken as haulm per net plot. The stalk yield per hectare was computed from plot yield and expressed as haulm yield in kg ha^{-1}.

3.6.2.5 Harvest index

It was calculated by using the formula.

$$\text{Harvest index} = \frac{\text{Seed yield per ha}}{\text{Seed + haulm yield per ha}}$$

3.7 Chemical analysis of soil and plant samples

The analyses of soil and plant samples were carried out by following the standard methods and procedures as given in Table 3.

Table 3: Standard methods and procedures used in the study

Sl. No.	Parameters	Method	Reference
Soil samples			
1	pH (1 **:** 2.5, soil : water)	Potentiometry	Jackson, 1973
2	EC (1 : 2.5, soil : water)	Conductometry	Jackson, 1973
3	Organic carbon	Wet oxidation method	Walkley and Black method, 1934
4	Available Nitrogen	Alkaline $KMnO_4$ method	Subbaiah and Asija, 1956
5	Available Phosphorus	Olsen's method	Jackson, 1973
6	Available Potassium	Neutral ammonium acetate method	Jackson, 1973
7	Available Sulpur	Turbidometric method	Jackson, 1973
8	Available micronutrients	DTPA extaction method	Lindsay and Norvell , 1978
9	Available Boron	Azomethine – H method	Berger & Troug (1939)
Plant samples			
1	Nitrogen	Micro Kjeldhal distilation method	Piper, 1966
2	Phosphorus	Vanadomolybdate yellow colour method	Piper, 1966
3	Potassium	Flame photometric method	Piper, 1966
4	Sulpur	Turbidometric method	Jackson, 1973
5	Micronutrients	Digestion with di acid mixture	Jackson, 1973
6	Boron	Dry ashing, Azomethane – H method	Berger & Troug (1939)
Biological properties			
1	Bacteria	Serial dilution and agar plate method	Pramer and Schmidt, 1964
2	Fungi	Serial dilution and agar plate method	Pramer and Schmidt, 1964
3	Actinomycetes	Serial dilution and agar plate method	Pramer and Schmidt, 1964
4	Dehydrogenase activity	TriphenylFormazan (TPF) method	Casida *et al.* 1964

3.7.1 Uptake of nutrients

Nitrogen content in chickpea was estimated by modified Kjeldhal's method as outlined by Jackson (1967) and expressed as percentage. Total phosphorus and potassium were extracted by wet ashing method. P was estimated by vanadomolybdo phosphoric yellow colour method (Jackson, 1967), K was determined by flame photometer method (Jackson, 1967) and S was determined by turbidometric method. Sum of uptake in grain and haulm was used to represent total uptake in kg ha^{-1}. Using the formula.

Total uptake was calculated by using following formula.

$$\text{Total uptake (kg ha}^{-1}\text{)} = \frac{\left(\begin{array}{c}\text{N concentration}\\ \text{in grain (\%)}\end{array}\right) \times \left(\begin{array}{c}\text{grain yield}\\ \text{(kg ha}^{-1}\text{)}\end{array}\right)}{100} + \frac{\left(\begin{array}{c}\text{N concentration}\\ \text{in straw (\%)}\end{array}\right) \times \left(\begin{array}{c}\text{Straw yield}\\ \text{(kg ha}^{-1}\text{)}\end{array}\right)}{100}$$

3.8 Analysis of microbial biomass and dehydrogenase activity in soil

Soil samples were collected from the rhizosphere of the plants at harvest. The soil samples collected were placed in a polyethylene bag and brought to laboratory and stored in refrigerator at 5^{0} C until used for analysis.

3.8.1 Enumeration of soil microorganisms

The rhizosphere soil samples collected from experimental soil were analyzed for different soil micro-organisms *viz*., bacteria, fungi and actinomycetes using standard dilution plate count technique and plating on specific nutrient media.

3.8.1.1 Enumeration of soil bacteria

Soil samples were sieved through 2 mm mesh to remove the bigger particles and debris and were used for isolation of bacteria. One ml of the 10^8 dilution of the soil suspension was pipette out on nutrient agar plates. The plates were incubated for 24h. at 28^{o}C. The colonies that appeared on nutrient agar media were enumerated and expressed in terms of cfu g^{-1} of soil on dry weight basis.

3.8.1.2 Enumeration of soil fungi

Soil samples were sieved through 2mm mesh to remove the bigger particles and debris and were used for isolation of bacteria. One ml of the 10^4 dilution of the soil suspension was pipette out on nutrient agar plates. The plates were incubated for 24h. at 28°C. The colonies that appeared on nutrient agar media were enumerated and expressed in terms of CFU g^{-1} of soil on dry weight basis.

3.8.1.3 Enumeration of soil actinomycetes

Soil samples were sieved through 2mm mesh to remove the bigger particles and debris and were used for isolation of bacteria. One ml of the 10^5 dilution of the soil suspension was pipette out on nutrient agar plates. The plates were incubated for 24h. at 28°C. The colonies that appeared on nutrient agar media were enumerated and expressed in terms of CFU g^{-1} of soil on dry weight basis.

3.8.1.4 Dehydrogenase activity (µg TPF/g soil)

The dehydrogenase activity in the soil samples was determined by following the procedure as described by Casida *et al.* (1964). Ten gram of soil and 0.2 g $CaCo_3$ were thoroughly mixed and dispensed in the conical flasks. Each flask was added with 1.0 ml of 1.5 per cent, 2, 3, 5-triphenyl tetrazolium chloride (TTC), 1.0 ml of 1 per cent glucose solution and 8.0 ml of distilled water to leave a thin film of water above soil layer. The flasks were stoppered with rubber bunks and incubated at 30 ^{0}C for 24 hours. At the end of incubation, the contents of the flask were rinsed down into small beaker and a slurry was made by adding 10 ml of methanol. The slurry was filtered through Whatman No. 42 filter paper.

The repeated rinsing of soil with methanol was continued till the filtrate ran free of red colour. The filtrate was made up to 50 ml with methanol in volumetric flask. The intensity of red colour was measured at 485 nm against a methanol blank using spectrometer. The Dehydrogenase activity was calculated using the formula.

$$\text{Dehydrogenase activty } (\mu g \text{ TPF g } 24 \text{ h.}^{-1}) = \frac{\text{Graph ppm x 33.7}}{\text{24 x Dry weight of soil}}$$

3.9 Economics of chickpea cultivation

B: C ratio were worked out by using the formula.

$$\text{Benefit: Cost (B: C)} = \frac{\text{Gross returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

3.10 Statistical analysis and the interpretation of data

Fisher's method of analysis of variance was used for analysis and interpretation of the data as outlined by Panse and Sukhatme (1967). The level of significance used in 'F' and 't' test was P = 0.05. Critical differences were calculated wherever 'F' test was significant.

IV. EXPERIMENTAL RESULTS

The results of the field experiment carried out to study the "Nutrient management in chickpea (*Cicer arietinum* L.) in black soil under rainfed situation" during *rabi* 2016-17 at Krishi Vijnana Kendra Farm, Kalaburagi, are presented in this chapter. Generally, application of inorganic fertilizers, organic manures combination with liquid fermented organic was compared to that of recommended nutrition system (RDF).

4.1 General characteristics of the experimental site

4.2 Effect of nutrient management practices on growth parameters

4.3 Effect of nutrient management practices on yield and yield parameters

4.4 Effect of nutrient management practices on nutrient content in grain and straw of chickpea

4.5 Effect of nutrient management practices on grain uptake

4.6 Effect of nutrient management practices on stalk nutrient uptake

4.7 Effect of nutrient management practices on total nutrient uptake by chickpea

4.8 Effect of nutrient management practices on available nutrient status in post harvest soil samples

4.9 Effect of nutrient management practices on soil microbial biomass

4.10 Effect of nutrient management practices on economics of chickpea cultivation.

4.1 General characteristics of the experimental site

The experiment was conducted at Krishi Vignana Kendra, Kalaburagi in Plot No. C-6 during *rabi,* 2016-17. Kalaburagi is situated in the North Eastern Dry Zone (Zone-2) of Karnataka between 17º 34' N latitude and 76º 79' E longitude with an altitude of 478 meters above the mean sea level.

The analysis results of surface composite soil sample collected from the experimental site are presented in Table 1. The soil was medium black with clay loam

Plate.1 General View of experimental plot of Chickpea crop

Plate.2 General View of experimental plot at 30 DAS of Chickpea crop

Plate.3 General View of experimental plot at 60 DAS of Chickpea crop

Plate.4 General View of experimental plot at harvest stage of Chickpea crop

Plate.5 Preparation of Jeevamrutha

texture. It had slightly alkaline pH (8.20), low EC (0.32 dS m^{-1}) and low in soil organic carbon content (0.47 %).

The soil was medium in available nitrogen (313.60 kg ha^{-1}), medium in available phosphorous (36.73 kg ha^{-1}), high potassium (642.62 kg ha^{-1}) and lower sulphur (12.88 kg ha^{-1}). The concentrations of DTPA extractable micronutrients *viz*., zinc, iron, cupper, manganese and boron were 0.92, 8.68, 2.80, 11.24 and 0.36 mg kg^{-1} respectively. And soil microbial counts for bacteria, fungi, actinomycetes and dehydrogenase activity were 15.45 (No. x 10^7 cfu g^{-1} of soil), 26.83 (No. x 10^5 cfu g^{-1} of soil), 10.58 (No. x 10^3 cfu g^{-1} of soil) and 16.73 (µg TPF h^{-1} g^{-1} soil) respectively.

4.2 Effect of nutrient management practices on growth parameters

The observations on growth parameters on chickpea were collected at different crop growth stages and are presented in the Table 4 and 7, respectively.

4.2.1 Plant height (cf. Table 4 and Fig 3)

The data pertaining to plant height of chickpea at different stages of crop growth revealed that due to various treatments in the experimentation have significantly influenced the plant height of chickpea at 30 DAS, 60 DAS and at harvest. (Table 4).

At 30 DAS, significantly higher plant height was recorded with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (26.70 cm) as compared to all other treatments. Significantly lower plant height was recorded with RDF (25.25 cm) which inturn was on par with rest of the treatments.

At 60 DAS, treatment with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher plant height (40.93 cm) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (40.43 cm) and VC @ 2.5 t ha^{-1} + Jeevamruta(40.37 cm). Treatment supplemented with only RDF recorded lower plant height (37.13 cm) and was on par with treatments supplied with FYM @ 5 t ha^{-1} + 50% RDF, RDF + Jeevamrutha, VC @ 2.5 t ha^{-1} + 50% RDF, FYM @ 5 t ha^{-1} + 75% RDF, VC @ 2.5 t ha^{-1} + 75% RDF, FYM @ 5 t ha^{-1} + Jeevamruta, along with FYM @ 5 t ha^{-1} + 100% RDF.

Table 4: Plant height at different growth stages of chickpea as influenced by nutrient management practices.

Treatment details	Plant height (cm)		
	30 DAS	**60 DAS**	**At Harvest**
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	25.25	37.43	42.01
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	25.81	37.50	42.04
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	26.03	37.30	42.80
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	26.39	39.70	43.32
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	26.59	39.97	43.97
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	26.00	39.19	42.68
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	26.34	39.61	42.89
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	27.01	40.43	44.43
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	26.61	40.37	44.08
T_{10} : RDF + Jeevamrutha	25.95	38.00	42.26
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	26.70	40.93	44.68
S.Em ±	**0.26**	**0.72**	**0.49**
CD (0.05)	**0.76**	**2.14**	**1.44**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

At harvest, significantly higher plant height was recorded with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (44.68 cm) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (44.43 cm). The next best treatments were application of VC @ 2.5 t ha^{-1} + Jeevamrutha (44.08 cm) and FYM @ 5 t ha^{-1} + Jeevamrutha (43.97 cm) along with FYM @ 5 t ha^{-1} + 100% RDF which were on par with each other. Significantly lower plant height was recorded with RDF (42.01 cm).

4.2.2 Number of branches per plant (cf. Table 5)

Number of branches per plant differed significantly due to different organic nutrient management systems at 30 and 60 DAS and at harvest.

At 30 DAS, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher number of branches per plant (4.83) and on par with the treatments receiving VC @ 2.5 t ha^{-1} + 100% RDF (4.80), VC @ 2.5 t ha^{-1} + Jeevamrutha (4.80), FYM @ 5 t ha^{-1} + Jeevamrutha (4.73), FYM @ 5 t ha^{-1} + 100% RDF (4.67), VC @ 2.5 t ha^{-1} + 75% RDF (4.60), FYM @ 5 t ha^{-1} + 75% RDF (4.37), VC @ 2.5 t ha^{-1} + 50% RDF (4.30) and RDF + Jeevamrutha (4.33) along with FYM @ 5 t ha^{-1} + 50% RDF(4.20). Significantly lower number of branches per plant was recorded with RDF alone (4.13).

At 60 DAS, treatment with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher number of branches per plant (6.80) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (6.67), VC @ 2.5 t ha^{-1} + Jeevamrutha (6.60) and FYM @ 5 t ha^{-1} + Jeevamrutha (6.60). Significantly lower number of branches per plant was recorded with RDF treatment (6.13) which inturn was on par with treatments supplemented with FYM @ 5 t ha^{-1} + 50% RDF (6.20), RDF + Jeevamrutha (6.33), VC @ 2.5 t ha^{-1} + 50% RDF (6.33), FYM @ 5 t ha^{-1} + 75% RDF (6.40) and VC @ 2.5 t ha^{-1} + 75% RDF (6.40) in combination with FYM @ 5 t ha^{-1} + 100% RDF (6.47).

At harvest, significantly higher number of branches per plant was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (8.40) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (8.33), VC @ 2.5 t ha^{-1} + Jeevamrutha (8.27), FYM @ 5 t ha^{-1} + Jeevamrutha (8.20) and VC @ 2.5 t ha^{-1} + 75% RDF (8.13). Treatment received RDF

Table 5: Number of branches per plant at different growth stages of chickpea as influenced by nutrient management practices.

TREATMENT DETAILS	No. of branches per plant		
	30 DAS	60 DAS	At Harvest
T_1 : RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})	4.13	6.13	7.87
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	4.20	6.20	7.93
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	4.37	6.40	8.07
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	4.67	6.47	8.20
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	4.73	6.60	8.20
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	4.33	6.33	8.00
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	4.60	6.40	8.13
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	4.80	6.67	8.33
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	4.80	6.60	8.27
T_{10} : RDF + Jeevamrutha	4.33	6.33	7.93
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	4.83	6.80	8.40
S.Em ±	**0.16**	**0.13**	**0.10**
CD (0.05)	**0.47**	**0.38**	**0.29**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

(7.87) resulted in significantly lower number of branches per plant and was found on par with rest of the treatments.

4.2.3 Dry matter accumulation in plant (cf. Table 6 and Fig 4)

Dry matter production differed significantly due to nutrient management practices at all the crop growth stages.

At 30 DAS, significantly higher dry matter production per plant was recorded with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (1.36 g $plant^{-1}$) when compare to all other treatments. The next best treatments were VC @ 2.5 t ha^{-1} + 100% RDF (1.32 g $plant^{-1}$), FYM @ 5 t ha^{-1} + Jeevamrutha (1.31 g $plant^{-1}$), VC @ 2.5 t ha^{-1} + Jeevamrutha (1.29 g $plant^{-1}$), FYM @ 5 t ha^{-1} + 100% RDF (1.22 g $plant^{-1}$) and VC @ 2.5 t ha^{-1} + 75% RDF (1.16 g $plant^{-1}$). Significantly lower dry matter production per plant was observed in control i,e RDF (0.94 g $plant^{-1}$) which inturn on par with the treatments supplemented with FYM @ 5 t ha^{-1} + 50% RDF (1.01 g $plant^{-1}$), RDF + Jeevamrutha (1.06 g $plant^{-1}$), VC @ 2.5 t ha^{-1} + 50% RDF (1.10 g $plant^{-1}$), FYM @ 5 t ha^{-1} + 75% RDF (1.12 g $plant^{-1}$).

At 60 DAS, application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher dry matter production (10.20 g $plant^{-1}$) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (9.78 g $plant^{-1}$) and VC @ 2.5 t ha^{-1} + Jeevamrutha (9.70 g $plant^{-1}$). Significantly lower dry matter production was recorded in RDF (7.28 g $plant^{-1}$) when compared to all other treatments.

At harvest, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher dry matter production per plant (28.9 g $plant^{-1}$) and was found on par with VC @ 2.5 t ha^{-1} + 100% RDF (28.60 g $plant^{-1}$) and VC @ 2.5 t ha^{-1} + Jeevamrutha (28.50 g $plant^{-1}$). The next best treatments were with FYM @ 5 t ha^{-1} + Jeevamrutha (28.40 g $plant^{-1}$) and FYM @ 5 t ha^{-1} + 100% RDF (27.9 g $plant^{-1}$). The treatment RDF showed significantly lower dry matter production per plant (26.20 g $plant^{-1}$) over rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (26.5 g $plant^{-1}$).

Table 6: Dry matter accumulation in crop at different growth stages of chickpea as influenced by nutrient management practices.

Treatment details	Dry matter production (g $plant^{-1}$)		
	30 DAS	60 DAS	At Harvest
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	0.94	7.28	26.2
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	1.01	7.35	26.5
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	1.12	7.95	27.0
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	1.22	9.11	27.9
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	1.31	9.38	28.4
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	1.10	7.61	26.9
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	1.16	8.45	27.4
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	1.32	9.78	28.6
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	1.29	9.70	28.5
T_{10} : RDF + Jeevamrutha	1.06	7.43	26.7
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	1.36	10.20	28.9
S.Em ±	**0.06**	**0.58**	**0.60**
CD (0.05)	**0.17**	**1.70**	**1.78**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

4.2.4 Number of root nodules per plant (cf. Table 7 and Fig 5)

The data on number of root nodules per plant differed significantly due to nutrient management practices at 40 and 60 DAS.

At 40 DAS, significantly higher number of root nodules per plant were noticed with treatment received FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (14.93) compared to all other treatments, and on par with VC @ 2.5 t ha^{-1} + 100% RDF (14.80), VC @ 2.5 t ha^{-1} + Jeevamrutha (14.53), FYM @ 5 t ha^{-1} + Jeevamrutha (14.27), FYM @ 5 t ha^{-1} + 100% RDF (14.20), VC @ 2.5 t ha^{-1} + 75% RDF (14.2) treatments, FYM @ 5 t ha^{-1} + 75% RDF (14.00). Significantly lower number of root nodules per plant were recorded with RDF (12.87) which inturn was on par with FYM @ 5 t ha^{-1} + 50% RDF (13.60) and RDF + Jeevamrutha (13.80)

At 60 DAS, application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (18.0), and on par with the treatments like VC @ 2.5 t ha^{-1} + 100% RDF (17.87), VC @ 2.5 t ha^{-1} + Jeevamrutha (17.60) and FYM @ 5 t ha^{-1} + Jeevamrutha (17.47) recorded significantly higher number of root nodules per plant over FYM @ 5 t ha^{-1} + 50% RDF (16.73), RDF(10:25:0) + Jeevamrutha (16.80), RDF + Jeevamrutha (16.80), VC @ 2.5 t ha^{-1} + 50% RDF (17.07) , FYM @ 5 t ha^{-1} + 75% RDF (17.20), VC @ 2.5 t ha^{-1} + 75% RDF (17.27), and FYM @ 5 t ha^{-1} + 100% RDF (17.43). Treatment supplemented with only RDF recorded significantly lower number of root nodules per plant (16.67).

4.3 Effect of nutrient management practices on yield and yield parameters

4.3.1 Number of pods per plant (cf. Table 8)

There were significant differences among the treatments with respect to number of pods per plant at harvest.

At harvest, number of pods per plant was significantly higher with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (87.60) as compared to other treatments except VC @ 2.5 t ha^{-1} + Jeevamrutha (86.40) and VC @ 2.5 t ha^{-1} + 100% RDF (86.27). The next best treatments were FYM @ 5 t ha^{-1} + Jeevamrutha (86.20), FYM @ 5 t ha^{-1} + 100% RDF (85.07) and VC @ 2.5 t ha^{-1} + 75% RDF (82.20) which

Table 7: Number of root nodules per plant at different growth stages of chickpea as influenced by nutrient management practices.

Treatment details	No. of root nodules per plant	
	40 DAS	**60 DAS**
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	12.87	16.67
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	13.60	16.73
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	14.00	17.20
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	14.20	17.43
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	14.27	17.47
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	13.93	17.07
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	14.20	17.27
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	14.80	17.87
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	14.53	17.60
T_{10} : RDF(10:25:0) + Jeevamrutha	13.80	16.80
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	14.93	18.00
S.Em ±	**0.31**	**0.19**
CD (0.05)	**0.90**	**0.57**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

Table 8: Number of pods per plant and test weight (100 seed weight) of chickpea as influenced by nutrient management practices.

Treatment details	**No. of pods per plant**	**Test weight (g)**
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	72.47	22.34
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	74.20	22.44
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	80.47	22.76
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	85.07	22.91
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	86.20	22.33
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	78.07	22.68
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	82.20	22.85
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	86.27	23.16
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	86.40	22.89
T_{10} : RDF + Jeevamrutha	76.57	22.51
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	87.60	23.21
S.Em ±	**2.10**	**0.16**
CD (0.05)	**6.19**	**0.48**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

were on par at each other. Treatment supplemented with only RDF recorded significantly lower number of pods per plant (72.47) and FYM @ 5 t ha^{-1} + 50% RDF (74.20).

4.3.2 Test weight (cf. Table 8 and Fig 6)

The data on test weight (100 seed weight) did differ significantly among the treatments. However, treatment FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded maximum test weight (23.21 g) followed by VC @ 2.5 t ha^{-1} + 100% RDF (23.16 g), FYM @ 5 t ha^{-1} + 100% RDF (22.91 g) and VC @ 2.5 t ha^{-1} + Jeevamrutha (22.89 g). The application of RDF registered the lower test weight (22.34 g).

4.3.3 Seed yield (cf. Table 9 and Fig 7)

Seed yield differed significantly due to different nutrient management practices through inorganics and organics treatments.

Among various treatments, application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher seed yield (1525.67 kg ha^{-1}) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (1395 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (1376.33 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (1352.00 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (1348.67 kg ha^{-1}). The treatments supplemented with VC @ 2.5 t ha^{-1} + 75% RDF (1330.33 kg ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (1287.00 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (1280.67 kg ha^{-1}), RDF + Jeevamrutha (1250.00 kg ha^{-1}),. Significantly lower seed yield was recorded in RDF (1117.33 kg ha^{-1}) which was found on par with FYM @ 5 t ha^{-1} + 50% RDF (1179.00 kg ha^{-1}).

4.3.4 Stover yield (cf. Table 9 and Fig 7)

Stover yield differed significantly among the treatments as influenced by different nutrient management practices through organics.

Significantly higher haulm yield was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (2243.00 kg ha^{-1}) as compared to other treatments, but it was found on par with other treatments *viz.*, VC @ 2.5 t ha^{-1} + 100% RDF (2137.33 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (2118.67 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (2094.33 kg ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (2091.00 kg ha^{-1}) and VC @ 2.5 t ha^{-1} +

Table 9: Seed yield, Stover yield and harvest index of chickpea as influenced by nutrient management practices.

Treatment details	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	1117.33	1859.00	0.60
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	1179.00	1921.33	0.61
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	1287.00	2029.00	0.63
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	1348.67	2091.00	0.64
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	1352.00	2094.33	0.64
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	1280.67	2023.00	0.63
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	1330.33	2072.67	0.64
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	1395.00	2137.33	0.65
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	1376.33	2118.67	0.65
T_{10} : RDF + Jeevamrutha	1250.00	1992.33	0.63
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	1525.67	2243.00	0.66
S.Em ±	**48**	**52**	**0.02**
CD (0.05)	**142**	**154**	**NS**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.
NS: Non Significant

75% RDF (2072.67 kg ha^{-1}). All these treatments recorded significantly higher stover yield over RDF alone (1906 kg ha^{-1}) which recorded lower haulm yield and was on par with rest of the treatments.

4.3.5 Harvest index (cf. Table 9)

The data on harvest index did not differ significantly due to different nutrient management practices through organics and inorganics. However, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (0.66) and VC @ 2.5 t ha^{-1} + 100% RDF (0.65) recorded higher harvest index as compared to rest of the treatments.

4.4 Effect of nutrient management practices on nutrient content in grain and straw of chickpea (Table 11)

The analysis of grain and straw of chickpea were carried out to study the major nutrient concentrations at harvest stage of chickpea. The data are presented in Tables 11).

4.4.1 Nitrogen

Significantly higher nitrogen content (3.94 % and 2.90 %) at harvest was recorded in grain and straw by the application FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamruthha. It was on par with treatment VC @ 2.5 t ha^{-1} + 100% RDF (3.88 % and 2.77 %). However, lower nitrogen content (2.38 % and 1.47 %) was recorded in RDF treatment.

4.4.2 Phosphorus

Significantly higher phosphors content in grain (0.81% and 0.60 %) at harvest was recorded in grain and straw by the application FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamruta. It was on par with VC @ 2.5 t ha^{-1} + 100% RDF (0.80 % and 0.59 %). However, lower nitrogen content (0.62 % and 0.40 %) was recorded in RDF treatment.

4.4.3 Potassium

Significantly higher potassium content of (4.11 % and 3.25 %) at harvest was recorded in grain and straw by the application FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. It was on par with the treatment VC @ 2.5 t ha^{-1} + 100% RDF (4.08 % and

Table 11: Nutrient concentration after harvest of the crop in grain and straw as influenced by nutrient management practices.

Treatment details	N (%)		P (%)		K (%)		S (%)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	2.38	1.47	0.62	0.40	2.18	1.58	0.88	0.61
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	2.55	1.60	0.63	0.42	2.35	1.71	0.90	0.62
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	2.88	1.97	0.68	0.46	3.03	2.17	0.94	0.69
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	3.35	2.43	0.73	0.50	3.64	2.63	0.98	0.72
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	3.46	2.60	0.75	0.53	3.83	2.84	1.00	0.73
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	2.80	1.87	0.66	0.45	2.52	2.36	0.92	0.66
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	3.23	2.23	0.71	0.48	3.39	2.40	0.96	0.71
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	3.88	2.77	0.80	0.59	4.08	3.14	1.03	0.77
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	3.70	2.67	0.78	0.56	4.05	3.01	1.02	0.75
T_{10} : RDF+ Jeevamrutha	2.69	1.77	0.65	0.43	2.51	1.88	0.91	0.64
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	3.94	2.90	0.81	0.60	4.11	3.25	1.06	0.81
S.Em ±	**0.16**	**0.14**	**0.04**	**0.03**	**0.08**	**0.11**	**0.06**	**0.04**
CD (0.05)	**0.48**	**0.41**	**0.12**	**0.10**	**0.24**	**0.32**	**0.16**	**0.12**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

3.14 %). However, lowest potassium content (2.18 % and 1.58 %) was recorded in treatment (RDF alone) compared to other treatments.

4.4.4 Sulphur

Significantly higher sulphur content of (1.06 % and 0.81 %) at harvest was recorded in grain and straw by the application FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. It was on par with the treatment VC @ 2.5 t ha^{-1} + 100% RDF (1.03 % and 0.77 %). However, lowest potassium content (0.88 % and 0.61 %) was recorded in treatment (RDF alone) compared to other treatments.

4.5 Effect of nutrient management practices on grain uptake (Table 12)

The analyses of grain of chickpea were carried out to study the major and micro nutrient uptake at harvest stage of chickpea. The data are presented in Tables 12.

4.5.1 Nitrogen uptake at harvest (cf. Table 12 and Fig 8)

The data on uptake of nitrogen in grain samples at harvest stage of crop growth significantly varied due to various treatments imposed.

Among different treatments, higher nitrogen uptake at harvest was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (56.22 kg ha^{-1}) application which was significantly superior over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (54.19 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (50.94 kg ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (46.49 kg ha^{-1}) which were on par with each other. All the treatments which received FYM, vermicompost, with inorganic fertilizers and Jeevamrutha were at par with each other. Treatment supplemented with only RDF recorded significantly lower nitrogen uptake (26.51 kg ha^{-1}) which inturn was on par with FYM @ 5 t ha^{-1} + 50% RDF (29.75 kg ha^{-1}), RDF + Jeevamrutha (33.45 kg ha^{-1}) and VC @ 2.5 t ha^{-1} + 50% RDF (35.84 kg ha^{-1}).

4.5.2 Phosphorus uptake at harvest (cf. Table 12 and Fig 9)

Different treatments had significant influence on uptake of phosphorus by chickpea at harvest.

Table 12: Total nutrient (grain + straw) uptake after harvest of the crop as influenced by nutrient management practices.

Treatment details	Concentration (%)				($kg\ ha^{-1}$)			
	N	**P**	**K**	**S**	**N**	**P_2O_5**	**K_2O**	**S**
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ $kg\ ha^{-1}$)	3.84	1.02	3.76	1.49	53.79	14.36	53.40	21.17
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	4.15	1.05	4.06	1.52	60.33	15.50	60.75	22.52
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	4.84	1.14	5.20	1.63	76.90	18.09	83.11	26.10
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	5.79	1.23	6.26	1.7	95.97	20.30	104.52	28.27
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	6.06	1.28	6.68	1.73	101.01	21.24	110.72	28.81
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	4.66	1.11	4.88	1.58	73.87	17.56	80.96	25.13
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	5.46	1.19	5.78	1.67	89.32	19.39	94.93	27.49
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	6.65	1.39	7.31	1.8	113.25	23.77	125.50	30.83
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	6.37	1.34	7.06	1.77	107.33	22.60	119.20	29.93
T_{10} : RDF + Jeevamrutha	4.46	1.08	4.39	1.55	68.82	16.69	68.98	24.13
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	6.84	1.41	7.35	1.87	119.11	24.56	129.07	32.67
S.Em ±	**0.25**	**0.06**	**0.10**	**0.07**	**4.51**	**1.23**	**3.60**	**1.60**
CD (0.05)	**0.72**	**0.19**	**0.30**	**0.21**	**13.30**	**3.64**	**10.62**	**4.71**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

Significantly higher phosphorus uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (11.55 kg ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (11.16 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (10.74 kg ha^{-1}) and FYM @ 5t ha^{-1} + Jeevamrutha (10.14 kg ha^{-1}). Significantly lower uptake of phosphorus was noticed with RDF (6.93 kg ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (7.43 kg ha^{-1}) and RDF + Jeevamrutha (8.13 kg ha^{-1}).

4.5.3 Potassium uptake at harvest (cf. Table 12 and Fig 10)

Among various treatments, significantly higher potassium uptake at harvest was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (58.66 kg ha^{-1}) which was on par with treatment supplemented with VC @ 2.5 t ha^{-1} + 100% RDF (58.37 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (55.42 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (51.33 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (49.50 kg ha^{-1}) along with RDF and found superior over rest of the treatments. Treatments *viz.,* FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha), VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha along with RDF recorded potassium grain uptake by chickpea. Significantly lower uptake of potassium was noticed with RDF (24.14 kg ha^{-1}) as compared to other treatments except FYM @ 5 t ha^{-1} + 50% RDF (27.92 kg ha^{-1}), RDF + Jeevamrutha (31.78 kg ha^{-1}) and VC @ 2.5 t ha^{-1} + 50% RDF (32.73 kg ha^{-1}).

4.5.4 Sulphur uptake at harvest (cf. Table 12 and Fig 11)

Among various treatments, significantly higher sulpur uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (15.11 kg ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (14.37 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (14.04 kg ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (13.52 kg ha^{-1}). Significantly lower uptake of sulpur was noticed with RDF (9.83 kg ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (10.61 kg ha^{-1}) and RDF + Jeevamruta (11.38 kg ha^{-1}).

4.5.5 Micronutrients on grain uptake (cf. Table 14 and Fig 12, 13, 14, 15)

Different treatments had significant influence on grain uptake of micronutrients by chickpea at harvest.

Significantly higher zinc uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (66.53 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (64.15 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (61.93 g ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (58.35 g ha^{-1}). Significantly lower uptake of zinc was noticed with RDF (41.56 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (43.09 g ha^{-1}) and RDF + Jeevamrutha (46.25 g ha^{-1}).

Among various treatments, significantly higher iron uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (248.25 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (314.13 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (308.09 g ha^{-1}), and FYM @ 5 t ha^{-1} + Jeevamrutha (298.97 g ha^{-1}). Significantly lower uptake of iron was noticed with RDF (234.92 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (243.14 g ha^{-1}) and RDF + Jeevamrutha (248.25 g ha^{-1}).

Significantly higher copper uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (25.86 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (23.09 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (22.52 g ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (20.22 g ha^{-1}). Significantly lower uptake of copper was noticed with RDF (9.68 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (10.15 g ha^{-1}), RDF + Jeevamrutha (11.72 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (13.64 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (15.44 g ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (17.96 g ha^{-1}), and FYM @ 5 t ha^{-1} + 100% RDF (18.18 g ha^{-1}).

Among various treatments, significantly higher manganese uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (60.03 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (57.85 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (55.17 g ha^{-1}), and FYM @ 5 t ha^{-1} + Jeevamrutha (51.33 g ha^{-1}). Significantly lower uptake of manganese was noticed with RDF (29.80 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (32.30 g ha^{-1}), RDF + Jeevamrutha (34.67 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (36.96 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (39.03 g ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (43.13 g ha^{-1}), and FYM @ 5 t ha^{-1} + 100% RDF (49.69 g ha^{-1}).

Table 14: Micronutrient uptake after harvest of the crop in grain and straw as influenced by nutrient management practices.

Treatment details	Zn ($g\ ha^{-1}$)		Fe ($g\ ha^{-1}$)		Cu ($g\ ha^{-1}$)		Mn ($g\ ha^{-1}$)		B ($g\ ha^{-1}$)	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	41.56	49.77	234.92	662.88	9.68	15.58	29.80	79.56	16.93	11.67
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	43.09	50.64	243.14	686.85	10.15	16.98	32.30	85.67	19.87	12.91
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	52.77	58.87	268.26	781.88	15.44	19.80	39.03	105.21	25.78	15.64
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	56.94	62.28	292.97	856.86	18.18	21.52	49.69	118.95	30.90	17.25
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	58.35	66.36	298.97	892.64	20.22	22.66	51.33	126.13	32.25	18.39
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	48.63	55.18	262.59	755.02	13.64	19.00	36.96	96.89	24.47	14.81
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	55.21	60.73	276.98	812.34	17.96	20.75	43.13	109.72	28.18	16.54
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	64.15	73.12	314.13	954.67	23.09	24.37	57.85	141.12	37.02	20.03
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	61.93	69.62	308.09	939.03	22.52	23.47	55.17	132.06	34.56	19.13
T_{10} : RDF + Jeevamrutha	46.25	53.05	248.25	702.32	11.72	18.17	34.67	92.58	22.81	13.99
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	66.53	75.88	327.90	978.89	25.86	26.25	60.03	151.76	40.09	21.92
S.Em ±	**1.23**	**1.07**	**7.36**	**33.41**	**1.46**	**1.39**	**2.31**	**4.33**	**0.08**	**0.05**
CD (0.05)	**3.63**	**3.17**	**21.72**	**98.57**	**4.30**	**4.09**	**6.83**	**12.76**	**0.24**	**0.15**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

Significantly higher boron uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (40.09 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (37.02g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (34.56 g ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (32.25 g ha^{-1}). Significantly lower uptake of boron was noticed with RDF (16.93g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (19.87 g ha^{-1}), RDF + Jeevamrutha (22.81 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (24.47 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (25.78 g ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (28.18 g ha^{-1}), and FYM @ 5 t ha^{-1} + 100% RDF (30.90 g ha^{-1}).

4.6 Effect of nutrient management practices on stalk nutrient uptake (cf. Table 12)

The analysis of straw of chickpea were carried out to study the major and micro nutrient uptake at harvest stage of chickpea. The data are presented in Tables 12.

4.6.1 Nitrogen uptake at harvest (cf. Table 12 and Fig 8)

The data on uptake of nitrogen in straw samples at harvest stage of crop growth significantly varied due to various treatments imposed.

Among different treatments, higher nitrogen uptake at harvest was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (62.89 kg ha^{-1}) application which was significantly superior over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (59.06 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (56.39 kg ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (54.52kg ha^{-1}) which were on par with each other. All the treatments which received FYM, vermicompost, with inorganic fertilizers and Jeevamruta were at par with each other. Treatment supplemented with only RDF recorded significantly lower nitrogen uptake (27.28 kg ha^{-1}) which inturn was on par with FYM @ 5 t ha^{-1} + 50% RDF (30.58 kg ha^{-1}), RDF(10:25:0) + Jeevamruta (35.37 kg ha^{-1}) and VC @ 2.5 t ha^{-1} + 50% RDF (38.02 kg ha^{-1}).

4.6.2 Phosphorus uptake at harvest (cf. Table 12 and Fig 9)

Different treatments had significant influence on straw uptake of phosphorus by chickpea at harvest.

Significantly higher phosphorus uptake was obtained with FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha application (13.01 kg ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (12.61 kg ha^{-1}, VC @ 2.5 t ha^{-1} + Jeevamrutha (11.86 kg ha^{-1}) and FYM @ 5t ha^{-1} + Jeevamrutha (11.10 kg ha^{-1}). Significantly lower uptake of phosphorus was noticed with RDF (7.44 kg ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (8.07 kg ha^{-1}) and RDF + Jeevamrutha (8.57 kg ha^{-1}).

4.6.3 Potassium uptake at harvest (cf. Table 12 and Fig 10)

Among various treatments, significantly higher potassium uptake at harvest was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (70.41 kg ha^{-1}) which was on par with treatment supplemented with VC @ 2.5 t ha^{-1} + 100% RDF (67.13 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (63.78 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (59.38 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (55.03 kg ha^{-1}) along with RDF and found superior over rest of the treatments. Treatments *viz.,* FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + LF (Jeevamruta), VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + LF(Jeevamruta) along with RDF recorded on par potassium stalk uptake by chickpea. Significantly lower uptake of potassium was noticed with RDF (29.26 kg ha^{-1}) as compared to other treatments except FYM @ 5 t ha^{-1} + 50% RDF (32.83 kg ha^{-1}), RDF + Jeevamrutha (37.20 kg ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (44.07 kg ha^{-1}), and VC @ 2.5 t ha^{-1} + 50% RDF (48.24kg ha^{-1}).

4.6.4 Sulphur uptake at harvest (cf. Table 12 and Fig 11)

Among various treatments, significantly higher sulpur uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (17.56 kg ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (16.46 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamruta (15.89kg ha^{-1}) and FYM @ 5t ha^{-1} + Jeevamruta (15.29 kg ha^{-1}). Significantly lower uptake of sulpur was noticed with RDF (11.34 kg ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (11.91 kg ha^{-1}) and RDF + Jeevamrutha (12.75 kg ha^{-1}).

4.6.5 Micronutrients in uptake straw (cf. Table 14 and Fig 12, 13, 14, 15)

Different treatments had significant influence on straw uptake of micronutrients by chickpea at harvest.

Significantly higher zinc uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (75.88 g ha^{-1}) over other treatments VC @ 2.5 t ha^{-1} + 100% RDF (73.12 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (69.62 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (66.36 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (62.28 g ha^{-1}), and VC @ 2.5 t ha^{-1} + 75% RDF (60.73 g ha^{-1}). Significantly lower uptake of zinc was noticed with RDF (49.77 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (50.64 g ha^{-1}), RDF + Jeevamrutha (53.05 g ha^{-1}), and VC @ 2.5 t ha^{-1} + 50% RDF (55.18 g ha^{-1}).

Among various treatments, significantly higher iron uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (978.89 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (954.67 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (939.03 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (892.64 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (856.86 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 75% RDF (812.34 g ha^{-1}). Significantly lower uptake of iron was noticed with RDF (662.88 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (686.85 g ha^{-1}) and RDF + Jeevamrutha (702.32 g ha^{-1}).

Significantly higher copper uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (26.25 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (24.37 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (23.47 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (22.66 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (21.52 g ha^{-1}), and VC @ 2.5 t ha^{-1} + 75% RDF (20.75 g ha^{-1}). Significantly lower uptake of copper was noticed with RDF (15.58 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (16.98 g ha^{-1}), RDF + Jeevamrutha (18.17 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (19.00 g ha^{-1}) and FYM @ 5 t ha^{-1} + 75% RDF (19.80 g ha^{-1}).

Among various treatments, significantly higher manganese uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (151.76 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (141.12 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (132.06 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (126.13 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (118.95 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 75% RDF (109.72 g ha^{-1}). Significantly lower uptake of manganese was noticed with RDF (79.56 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (85.67 g ha^{-1}), RDF + Jeevamrutha (92.58 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (96.89 g ha^{-1}), and FYM @ 5 t ha^{-1} + 75% RDF (105.21 g ha^{-1}).

Significantly higher boron uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (21.92 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (20.03 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (19.13 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (18.39 g ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (17.25 g ha^{-1}). Significantly lower uptake of boron was noticed with RDF (11.67 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (12.91 g ha^{-1}), RDF + Jeevamrutha (13.99 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (14.81 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (15.64 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 100% RDF (20.03g ha^{-1}).

4.7 Effect of nutrient management practices on total nutrient uptake by chickpea

4.7.1 Major nutrient uptake by chickpea (cf. Table 13)

The major nutrient uptake (kg ha^{-1}) of chickpea at harvest stage of crop as influenced by different treatments in the experimentation is presented in the Table 13.

The data on nitrogen, phosphorus potassium and sulpur uptake by stalk and grain of chickpea were statistically significant.

Among different treatments, higher nitrogen uptake at harvest was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (119.11 kg ha^{-1}) application which was significantly superior over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (113.25 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (107.33 kg ha^{-1}) and FYM @ 5t ha^{-1} + Jeevamrutha (107.33 kg ha^{-1}). All the treatments which received FYM, vermicompost , with inorganic fertilizers and Jeevamruta were at par with each other. Treatment supplemented with only RDF recorded significantly lower nitrogen uptake (53.79 kg ha^{-1}) which inturn was on par with FYM @ 5 t ha^{-1} + 50% RDF (60.33 kg ha^{-1}), RDF +

Jeevamrutha (68.82 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (73.87 kg ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (76.90 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (89.32 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (95.97 kg ha^{-1}).

Significantly higher phosphorus uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (24.56 kg ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (23.77 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (22.60 kg ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (21.24 kg ha^{-1}). Significantly lower uptake of phosphorus was noticed with RDF (14.36 kg ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (15.50 kg ha^{-1}) , RDF + Jeevamrutha (16.69 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (17.56 kg ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (18.09 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (19.39 kg ha^{-1}), and FYM @ 5 t ha^{-1} + 100% RDF (20.30 kg ha^{-1}).

Among various treatments, significantly higher potassium uptake at harvest was recorded with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (129.07 kg ha^{-1}) which was on par with treatment supplemented with VC @ 2.5 t ha^{-1} + 100% RDF (125.50 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (119.20 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (110.72 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (104.52 kg ha^{-1}) along with RDF and found superior over rest of the treatments. Treatments *viz.,* FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha, VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha recorded on par potassium grain uptake by chickpea. Significantly lower total uptake of potassium was noticed with RDF (53.40 kg ha^{-1}) as compared to other treatments except FYM @ 5 t ha^{-1} + 50% RDF (60.75 kg ha^{-1}), RDF + Jeevamrutha (68.98 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (80.96 kg ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (83.11 kg ha^{-1}) and VC @ 2.5 t ha^{-1} + 75% RDF (94.93 kg ha^{-1}).

Among various treatments, significantly higher sulphur uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (32.67 kg ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (30.83 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (29.93 kg ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (28.81kg ha^{-1}). Significantly lower uptake of sulphur was noticed with RDF (21.17 kg ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (22.52 kg ha^{-1}), RDF +

Table 13: Nutrient uptake after harvest of the crop in grains and straw as influenced by nutrient management practices.

Treatment details	N (kg ha^{-1})		P (kg ha^{-1})		K (kg ha^{-1})		S (kg ha^{-1})	
	Grain	Straw	Grain	Straw	Grain	Straw	Grain	Straw
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	26.51	27.28	6.93	7.44	24.14	29.26	9.83	11.34
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	29.75	30.58	7.43	8.07	27.92	32.83	10.61	11.91
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	37.00	39.90	8.75	9.33	39.05	44.07	12.10	14.00
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	45.18	50.80	9.85	10.46	49.50	55.03	13.22	15.06
T_5 : FYM @ 5t ha^{-1} + Jeevamrutha	46.49	54.52	10.14	11.10	51.33	59.38	13.52	15.29
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	35.84	38.02	8.45	9.10	32.73	48.24	11.78	13.35
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	42.99	46.33	9.45	9.95	45.21	49.72	12.77	14.72
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	54.19	59.06	11.16	12.61	58.37	67.13	14.37	16.46
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	50.94	56.39	10.74	11.86	55.42	63.78	14.04	15.89
T_{10} : RDF + Jeevamrutha	33.45	35.37	8.13	8.57	31.78	37.20	11.38	12.75
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	56.22	62.89	11.55	13.01	58.66	70.41	15.11	17.56
S.Em ±	**2.28**	**3.13**	**0.69**	**0.75**	**2.04**	**2.98**	**0.98**	**1.02**
CD (0.05)	**6.73**	**9.24**	**2.04**	**2.23**	**6.01**	**8.80**	**2.89**	**3.00**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

Jeevamrutha (24.13 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (25.13 kg ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (26.10 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (27.49 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (28.27 kg ha^{-1}).

4.7.2 Micronutrient uptake by chickpea (cf. Table 15)

The micronutrient uptake by chickpea as influenced by different treatments in the study is presented in the Table 16.

The data on uptake of Zn, Fe, Cu, Mn and B by stalk and grain of chickpea were statistically significant.

Significantly higher zinc uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (142.41 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (137.27 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (131.56 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (124.70 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (119.21 g ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (115.94 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (111.64 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 50% RDF (103.81g ha^{-1}). Significantly lower uptake of zinc was noticed with RDF (91.33 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (93.73 g ha^{-1}), and VC @ 2.5 t ha^{-1} + Jeevamrutha (131.56 g ha^{-1}).

Among various treatments, significantly higher iron uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (1306.80 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (1268.80 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (1247.11 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (1191.61 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (1149.83 g ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (1089.32 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (1050.13 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 50% RDF (1017.61 g ha^{-1}). Significantly lower uptake of iron was noticed with RDF (897.80 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (929.98 g ha^{-1}) and RDF + Jeevamrutha (950.57 g ha^{-1}).

Significantly higher copper uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (52.11 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (47.46 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (45.99 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (42.88 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (39.70 g ha^{-}

Table 15: Total micronutrient (grain + straw) uptake after harvest of the crop as influenced by nutrient management practices.

Treatment details	Micronutrient (g ha^{-1})				
	Zn	**Fe**	**Cu**	**Mn**	**B**
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	91.33	897.80	25.26	109.35	28.60
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	93.73	929.98	27.13	117.97	32.78
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	111.64	1050.13	35.25	144.24	41.42
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	119.21	1149.83	39.70	168.64	48.15
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	124.70	1191.61	42.88	177.46	50.63
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	103.81	1017.61	32.63	133.85	39.28
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	115.94	1089.32	38.71	152.85	44.72
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	137.27	1268.80	47.46	198.97	57.05
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	131.56	1247.11	45.99	187.23	53.69
T_{10} : RDF + Jeevamrutha	99.30	950.57	29.89	127.24	36.80
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	142.41	1306.80	52.11	211.79	62.01
S.Em ±	**1.93**	**33.99**	**1.85**	**5.44**	**0.08**
CD (0.05)	**5.71**	**100.28**	**5.46**	**16.05**	**0.24**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

^{1}), and VC @ 2.5 t ha^{-1} + 100% RDF (47.46 g ha^{-1}). Significantly lower uptake of copper was noticed with RDF (25.26 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (27.13 g ha^{-1}), RDF + Jeevamrutha (29.89 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (32.63 g ha^{-1}) and FYM @ 5 t ha^{-1} + 75% RDF (35.25 g ha^{-1}).

Among various treatments, significantly higher manganese uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (211.79 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (198.97 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (187.23 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (177.46 g ha^{-1}), FYM @ 5 t ha^{-1} + 100% RDF (168.64 g ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (152.85 g ha^{-1}) and FYM @ 5 t ha^{-1} + 75% RDF (144.24 g ha^{-1}). Significantly lower uptake of manganese was noticed with RDF (109.35 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (117.97 g ha^{-1}), RDF + Jeevamrutha (127.24 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 50% RDF (133.85 g ha^{-1}).

Significantly higher boron uptake was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (62.01 g ha^{-1}) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (57.05 g ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (53.69 g ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (50.63 g ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (48.15 g ha^{-1}). Significantly lower uptake of boron was noticed with RDF (28.60 g ha^{-1}) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (32.78 g ha^{-1}), RDF + Jeevamrutha (36.80 g ha^{-1}), VC @ 2.5 t ha^{-1} + 50% RDF (39.28 g ha^{-1}), FYM @ 5 t ha^{-1} + 75% RDF (41.42 g ha^{-1}) and VC @ 2.5 t ha^{-1} + 75% RDF (44.72 g ha^{-1}).

4.8 Effect of nutrient management practices on available nutrient status in post harvest soil samples

The available nutrient status for both major and micronutrients in post harvest soil samples are presented in Table 16 and 17.

4.8.1 Soil reaction (pH) (cf. Table 10)

Soil reaction did not differ significantly among the treatments after harvest of chickpea.

Table 10: chemical properties of soil after harvest of the crop as influenced by nutrient management practices.

Treatment details	pH (1 : 2.5)	EC (dSm^{-1})	OC (%)
Initial values	**8.20**	**0.32**	**0.47**
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	8.25	0.34	0.46
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	8.09	0.32	0.52
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	8.10	0.33	0.51
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	8.13	0.33	0.52
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	8.17	0.30	0.50
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	8.19	0.30	0.50
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	8.21	0.31	0.51
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	8.18	0.32	0.49
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	8.17	0.30	0.47
T_{10} : RDF + Jeevamrutha	8.23	0.33	0.48
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	8.07	0.28	0.54
S.Em ±	**0.21**	**0.01**	**0.02**
CD (0.05)	**NS**	**NS**	**NS**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.
NS: Non Significant

4.8.2 Electric conductivity of soil (cf. Table 10)

Electric conductivity did not differ significantly among the treatments after harvest of chickpea.

4.8.3 Organic carbon content of soil (cf. Table 10)

Organic carbon content in soil did not differ significantly among the treatments after harvest of chickpea.

4.8.4 Available soil nitrogen (cf. Table 16 and Fig 16)

The data on available nitrogen in the soil showed significant differences among treatments as influenced by after harvest of chickpea. Significantly higher available nitrogen was recorded with the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (219.52 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 100% RDF (206.45 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (203.84 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (196.00 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (193.39 kg ha^{-1}). Significantly lower available soil nitrogen was recorded with treatments received with RDF alone (172.48 kg ha^{-1}) when compared to all other treatments.

4.8.5 Available soil phosphorus (cf. Table 16 and Fig 16)

Available soil phosphorus differed significantly as influenced by treatments after harvest of chickpea. Available phosphorus in soil was significantly higher with treatments supplemented with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (29.57 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 100% RDF (29.12 kg ha^{-1}) and VC @ 2.5 t ha^{-1} + Jeevamrutha (28.52 kg ha^{-1}). Treatment supplemented with only RDF recorded significantly lower available soil phosphorus (24.90 kg ha^{-1}) when compared to rest of the treatments.

4.8.6 Available soil potassium (cf. Table 16 and Fig 16)

Soil available potassium differed significantly due to different nutrient treatments after harvest of the crop. Available potassium content of soil was significantly higher with the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (543.20 kg ha^{-1}) which was closely followed by VC @ 2.5 t ha^{-1} + 100% RDF (537.67 kg ha^{-1}), VC @

Table 16: Available nutrient (kg/ha) after harvest of the crop as influenced by nutrient management practices.

Treatment details	**Available nutrient (kg/ha)**			
	N	**P_2O_5**	**K_2O**	**SO_4**
T_1 : RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})	172.48	24.90	442.62	12.11
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	180.32	25.83	453.97	13.04
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	188.16	27.18	482.20	14.60
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	193.39	27.78	508.33	15.57
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	196.00	28.07	516.84	16.04
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	185.55	26.73	475.33	14.03
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	190.77	27.33	493.55	15.09
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	206.45	29.12	537.67	16.82
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	203.84	28.52	528.86	16.38
T_{10} : RDF + Jeevamrutha	182.93	26.13	473.83	13.54
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	219.52	29.57	543.20	17.06
S.Em ±	**6.55**	**0.93**	**13.23**	**0.97**
CD (0.05)	**19.31**	**2.74**	**39.03**	**2.86**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

2.5 t ha^{-1} + Jeevamrutha (528.86 kg ha^{-1}) and FYM @ 5 t ha^{-1} + Jeevamrutha (516.84 kg ha^{-1}) treatments. These treatments were found superior over FYM @ 5 t ha^{-1} + 75% RDF (482.20 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 75% RDF (493.55 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (508.33 kg ha^{-1}). Significantly lower availability of potassium was noticed with RDF alone (442.62 kg ha^{-1}).

4.8.7 Available soil sulpur (cf. Table 16 and Fig 16)

The data on available sulpur in the soil showed significant differences among treatments as influenced by after harvest of chickpea. Significantly higher available sulpur was recorded with the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamruta (17.06 kg ha^{-1}), VC @ 2.5 t ha^{-1} + 100% RDF (16.82 kg ha^{-1}), VC @ 2.5 t ha^{-1} + Jeevamrutha (16.38 kg ha^{-1}), FYM @ 5 t ha^{-1} + Jeevamrutha (16.04 kg ha^{-1}) and FYM @ 5 t ha^{-1} + 100% RDF (15.57 kg ha^{-1}). Significantly lower available soil sulpur was recorded with treatments received with RDF alone (12.11 kg ha^{-1}) when compared to all other treatments.

4.8.8 Available micronutrient status (cf. Table 17 and Fig 17)

The available micronutrient status after harvest of chickpea as influenced by different treatments in the study is presented in the Table 17.

The data on available micronutrients like Zn, Fe, Cu, Mn, and B by harvest of chickpea were statistically significant.

Significantly higher available zinc was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (0.973 ppm) over other treatments except VC @ 2.5 t ha^{-1} + 75% RDF (0.961 ppm), VC @ 2.5 t ha^{-1} + 50% RDF (0.953 ppm), RDF(10:25:0) + Jeevamrutha (0.933 ppm), FYM @ 5 t ha^{-1} + Jeevamrutha (0.893 ppm), VC @ 2.5 t ha^{-1} + 100% RDF (0.880 ppm), FYM @ 5 t ha^{-1} + 100% RDF (0.867 ppm), FYM @ 5 t ha^{-1} + 75% RDF (0.860 ppm). Significantly lower available zinc was noticed with VC @ 2.5 t ha^{-1} + Jeevamrutha (0.813 ppm) as compared to rest of the treatments except RDF (0.833 ppm), and FYM @ 5 t ha^{-1} + 50% RDF (0.857 ppm).

Among various treatments, significantly higher available iron was obtained with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application (6.58 ppm) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (6.45 ppm), RDF(10:25:0) + Jeevamrutha (6.45 ppm), FYM @ 5 t ha^{-1} + 100% RDF (6.37 ppm), FYM @ 5 t ha^{-1} + 75% RDF (6.34 ppm), VC @ 2.5 t ha^{-1} + Jeevamrutha (6.31 ppm), VC @ 2.5 t ha^{-1} + 50% RDF (6.30 ppm), and VC @ 2.5 t ha^{-1} + 75% RDF (6.28 ppm). Significantly lower available iron was noticed with RDF (6.15 ppm) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (6.21 ppm) and FYM @ 5 t ha^{-1} + Jeevamrutha (6.26 ppm).

Significantly higher available cupper was obtained with FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha (2.95 ppm) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (2.87 ppm), VC @ 2.5 t ha^{-1} + Jeevamrutha (2.76 ppm), RDF + Jeevamrutha (2.75 ppm), VC @ 2.5 t ha^{-1} + 75% RDF (2.70 ppm), FYM @ 5 t ha^{-1} + 75% RDF (2.69 ppm), and FYM @ 5 t ha^{-1} + 100% RDF (2.69 ppm). Significantly lower available cupper was noticed with RDF (2.52 ppm) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (2.60 ppm), VC @ 2.5 t ha^{-1} + 50% RDF (2.62 ppm) and FYM @ 5 t ha^{-1} + Jeevamrutha (2.68 ppm).

Among various treatments, significantly higher available manganese was obtained with FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha application (5.52 ppm) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (5.45 ppm), FYM @ 5 t ha^{-1} + 100% RDF (5.39 ppm), VC @ 2.5 t ha^{-1} + Jeevamrutha (5.31 ppm), FYM @ 5t ha^{-1} + Jeevamrutha (5.28 ppm), VC @ 2.5 t ha^{-1} + 75% RDF (5.20 ppm), RDF + Jeevamrutha (5.14 ppm). and FYM @ 5 t ha^{-1} + 75% RDF (5.10 ppm). Significantly lower available manganese was noticed with RDF (4.91 ppm) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (4.96 ppm) and VC @ 2.5 t ha^{-1} + 50% RDF (5.08 ppm).

Significantly higher available boron was obtained with FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutah application (0.438 ppm) over other treatments except VC @ 2.5 t ha^{-1} + 100% RDF (0.413 ppm), VC @ 2.5 t ha^{-1} + Jeevamrutha (0.388 ppm), FYM @ 5 t ha^{-1} + Jeevamrutha (0.371 ppm) and FYM @ 5 t ha^{-1} + 100% RDF (0.342 ppm).

Table 17: Available micronutrient status of soil after harvest of the crop as influenced by nutrient management practices.

Treatment details	Available micronutrient (ppm)				
	Zn	Fe	Cu	Mn	B
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	0.833	6.153	2.52	4.913	0.196
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	0.857	6.213	2.60	4.967	0.208
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	0.860	6.347	2.69	5.107	0.288
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	0.867	6.373	2.69	5.393	0.342
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	0.893	6.267	2.68	5.287	0.371
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	0.953	6.300	2.62	5.080	0.263
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	0.961	6.287	2.70	5.207	0.317
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	0.880	6.453	2.87	5.453	0.413
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	0.813	6.313	2.76	5.313	0.388
T_{10} : RDF + Jeevamrutha	0.933	6.453	2.75	5.140	0.233
T_{11} : FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha	0.973	6.587	2.95	5.520	0.438
S.Em ±	**0.03**	**0.06**	**0.07**	**0.1**	**0.04**
CD (0.05)	**0.1**	**0.19**	**0.22**	**0.31**	**0.11**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

Significantly lower available boron was noticed with RDF (0.196 ppm) as compared to rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (0.208 ppm), RDF + Jeevamrutha (0.233 ppm), VC @ 2.5 t ha^{-1} + 50% RDF (0.263 ppm), FYM @ 5 t ha^{-1} + 75% RDF (0.288 ppm) and VC @ 2.5 t ha^{-1} + 75% RDF (0.317 ppm).

4.9 Effect of nutrient management practices on soil microbial counts (cf. Table 18 and Fig 18)

The soil microbes like bacteria, fungi, actinomycetes and degydrogenase activity after harvest of chickpea as influenced by different organic and inorganic treatments in the study is presented in the Table 18.

The data on soil microbial counts for bacteria, fungi, actinomycetes and degydrogenase activity by harvest of chickpea were statistically significant.

4.9.1 Bacteria: (No. X 10^7 cfu g^{-1} of soil)

At harvest, significantly higher bacterial counts was recorded in FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (28.49) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (27.66), VC @ 2.5 t ha^{-1} + Jeevamrutha (27.22) and FYM @ 5 t ha^{-1} + Jeevamrutha (26.57). Significantly lower bacterial counts was recorded with RDF (21.61) over rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (22.12), RDF + Jeevamrutha (22.77), VC @ 2.5 t ha^{-1} + 50% RDF (23.84), FYM @ 5 t ha^{-1} + 75% RDF (24.19), VC @ 2.5 t ha^{-1} + 75% RDF (25.21) and FYM @ 5 t ha^{-1} + 100% RDF (26.57).

4.9.2 Fungi : (No. X 10^5 cfu g^{-1} of soil)

Among all the treatments at harvest, significantly higher fungal counts was recorded in FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (38.56) and was on par with VC @ 2.5 t ha^{-1} + Jeevamrutha (37.33), VC @ 2.5 t ha^{-1} + 100% RDF (37.19) and FYM @ 5 t ha^{-1} + Jeevamrutha (35.43). Significantly lower fungal counts was recorded with RDF (31.21) over rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (32.16), RDF + LF(Jeevamruta) (32.96), VC @ 2.5 t ha^{-1} + 50% RDF (32.98), FYM @ 5 t ha^{-1} + 75% RDF (33.87), VC @ 2.5 t ha^{-1} + 75% RDF (34.52) and FYM @ 5 t ha^{-1} + 100% RDF (34.79).

Table 18: Soil microbial counts and Dehydrogenase activity of soil after harvest of the crop as influenced by nutrient management practices.

Treatment details	Bacteria (No. X 10^7 cfu g^{-1} of soil)	Fungi (No. X 10^5 cfu g^{-1} of soil)	Actinomycetes (No. X 10^3 cfu g^{-1} of soil)	Dehydrogenase activity (µg TPF h^{-1} g^{-1} soil)
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	21.61	31.21	14.70	7.17
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	22.12	32.16	15.04	8.35
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	24.19	33.87	16.89	9.89
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	26.18	34.79	18.17	10.93
T_5 : FYM @ 5 t ha^{-1} + Jeevamrutha	26.57	35.43	18.41	11.54
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	23.84	32.98	16.33	9.54
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	25.21	34.52	17.47	10.66
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	27.66	37.19	19.72	12.86
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	27.22	37.33	19.36	12.61
T_{10} : RDF + Jeevamrutha	22.77	32.96	15.69	8.61
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	28.49	38.56	21.13	13.11
S.Em ±	**1.20**	**1.45**	**1.13**	**1.12**
CD (0.05)	**3.54**	**4.28**	**3.33**	**3.31**

RDF: Recommended Dose of Fertilizer, **FYM:** Farm Yard Manure, **VC:** Vermicompost.

4.9.3 Actinomycetes: (No. X 10^7 cfu g^{-1} of soil)

At harvest, significantly higher actinomycetes counts was recorded in FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (21.13) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (19.72), VC @ 2.5 t ha^{-1} + Jeevamrutha (19.36) and FYM @ 5 t ha^{-1} + Jeevamrutha (18.41). Significantly lower actinomycetes counts was recorded with RDF (14.70) over rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (15.04), RDF + Jeevamrutha (15.69), VC @ 2.5 t ha^{-1} + 50% RDF (16.33), FYM @ 5 t ha^{-1} + 75% RDF (16.89), VC @ 2.5 t ha^{-1} + 75% RDF (17.47) and FYM @ 5 t ha^{-1} + 100% RDF (18.17).

4.9.4 Dehydrogenase activity: (µg TPF h^{-1} g^{-1} soil)

Among all the treatments at harvest, significantly higher dehydrogenase activity was recorded in FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha (13.11) and was on par with VC @ 2.5 t ha^{-1} + 100% RDF (12.86), VC @ 2.5 t ha^{-1} + Jeevamrutha (12.61) and FYM @ 5 t ha^{-1} + Jeevamrutha (11.54). Significantly lower dehydrogenase activity was recorded with RDF (7.17) over rest of the treatments except FYM @ 5 t ha^{-1} + 50% RDF (8.35), RDF + LF(Jeevamruta) (8.61), VC @ 2.5 t ha^{-1} + 50% RDF (9.54), FYM @ 5 t ha^{-1} + 75% RDF (9.89), VC @ 2.5 t ha^{-1} + 75% RDF (10.66) and FYM @ 5 t ha^{-1} + 100% RDF (10.93).

4.10 Effect of nutrient management practices on economics of chickpea cultivation (Table 19)

Application of (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha was recorded the maximum cost of cultivation (Rs. 31145 ha^{-1}) and minimum cost of cultivation was recorded in (T_1) control (Rs. 25060 ha^{-1}). Higher gross returns (Rs. 67257 ha^{-1}) in treatment combination of (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha and lowest gross returns (Rs. 47317 ha^{-1}) was obtained in control (T_1). Higher net returns (Rs. 36112 ha-1) were recorded in (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha Lowest net return was observed in (T_1) control (Rs. 22257 ha^{-1}). Higher B:C ratio (Rs.2.16 ha^{-1}) was recorded in (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha, lowest B:C ratio (Rs.1.89 ha^{-1}) recorded in control (T_1).

Table 19: Economics of chickpea as influenced by nutrient management practices.

TREATMENT DETAILS	Cost of cultivation (Rs. ha^{-1})	Gross Returns (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	B:C ratio
T_1 : RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})	25060	47317	22257	1.89
T_2 : FYM @ 5 t ha^{-1} + 50% RDF	25185	47841	22656	1.90
T_3 : FYM @ 5 t ha^{-1} + 75% RDF	26859	52905	26046	1.97
T_4 : FYM @ 5 t ha^{-1} + 100% RDF	29560	59016	27976	2.10
T_5 : FYM @ 5t ha^{-1} + Jeevamrutha	29570	59714	30144	2.02
T_6 : VC @ 2.5 t ha^{-1} + 50% RDF	27725	52905	25180	1.91
T_7 : VC @ 2.5 t ha^{-1} + 75% RDF	28899	56048	27149	1.94
T_8 : VC @ 2.5 t ha^{-1} + 100% RDF	30820	61111	30291	1.98
T_9 : VC @ 2.5 t ha^{-1} + Jeevamrutha	30670	60064	29394	1.96
T_{10} : RDF + Jeevamrutha	26975	51857	24882	1.92
T_{11} : FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha	31145	67257	36112	2.16

V. DISCUSSION

The results obtained from the study carried out on the nutrient management in chickpea (*Cicer arietinum* L.) in black soil under rainfed situation in North Eastern Dry Zone of Karnataka (Zone-2) which are presented in chapter –V are discussed below.

Organic agriculture has grown out of the conscious efforts by inspired people to create the best possible relationship between the earth and men. Now organic agriculture is getting wider acceptance and recognition as sustainable alternative. Modern organic agriculture farm has environmental sustainability and optimization of productivity as its core in addition to the founders concerns for the healthy soil, healthy food and healthy people. The long felt information crunch and scientific explanation are being addressed. In this context, the present study is undertaken to identify the nutrient management practices through organics and inorganics for chickpea production under black soil rainfed situation in a given ecosystem. The study has brought out some useful results which are discussed in this chapter under the following subheads.

5.1 Effect of weather on crop performance

5.2 Effect of nutrient management practices through organics and inorganics on growth parameters of chickpea

5.3 Nutrient content and total uptake

5.4 Available nutrients in soil as influenced by integrated nutrient management practices

5.5 Effect of organic and inorganic sources of nutrients on soil microbial process.

5.6 Economics of chickpea cultivation

5.1 Effect of weather on crop performance

Kalaburagi is situated in the North Eastern Dry Zone of Karnataka (Zone-2) at 17^{o} 34$^{'}$ N latitude and 76^{o} 79$^{'}$ E longitude with an altitude of 478 meter above mean sea level. Crop was raised under black soil rainfed situation of zone-2 at Krishi Vignana Kendra, Kalaburagi with an average annual rainfall of 630.40 mm. The rainfall received during

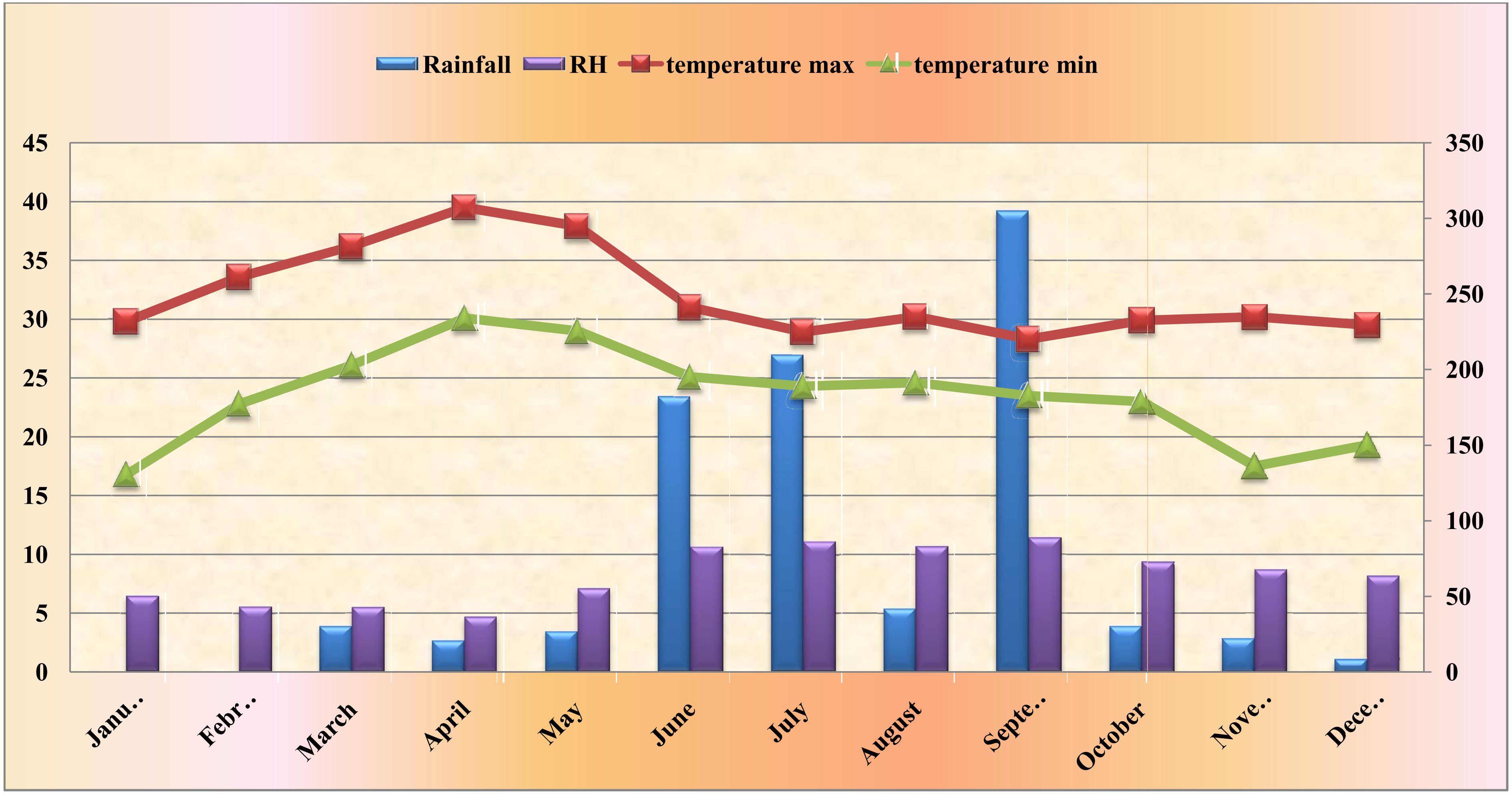

Fig.1: Mean monthly meteorological data for the year 2016-17 at the Agricultural Research Station, Kalaburagi.

the year of experimentation was 877.70 mm. During the crop growth period, the rainfall received was normal and its proper distribution favoured the crop to put up its normal growth. The mean minimum and maximum temperature and relative humidity during crop growth period of KVK, Kalaburagi given in Table 2.

5.2 Effect of nutrient management practices through organics and inorganics on growth parameters of chickpea

5.2.1 Growth parameters

The data obtained by conducting the experiment revealed that the application of sources of organic and inorganics as per different treatments had significant influence on plant height, number of branches, total dry matter production and number of root nodules per plant at different stages of crop growth are presented in Table 4 to 7.

At harvest, significantly highest plant height and number of branches plant^{-1} were recorded in T_{11} treatment which received application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. However, lowest plant height and number of branches plant^{-1} were recorded in T_1 (RDF alone). It might be due to application of organic manures in combination with inorganic fertilizers to the soil, resulted in increased the availability of nutrients considerably which intern improvement in growth parameters. These findings are in accordance with the results of Babalad 1999 who had observed increased plant height, number of trifoliate leaves plant^{-1} and number of branches plant^{-1} in soybean due to application of organic manure and inorganic fertilizers. Similar results were reported by Sharma and Dixit 1987.

5.2.2 Yield parameters

The yield attributing parameters such as number of pods plant^{-1} test weight and seed yield plant^{-1} were significantly influenced by application of sources of organic and inorganic on chickpea are presented in Table 8 & 9.

The highest yield components were found when the crop was fertilized with application of (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. Lowest were recorded in T_1 (100 % RDF alone) treatment. It might be due to the higher availability of

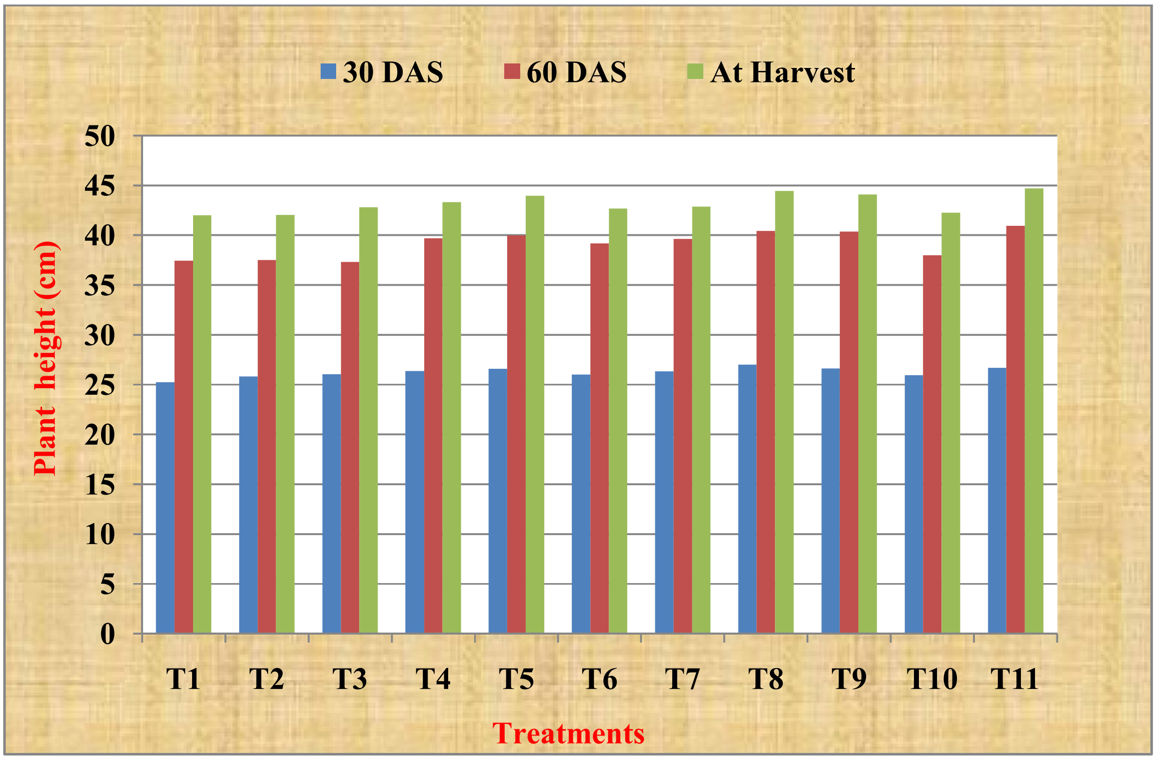

Fig.3: Plant height at different growth stages of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

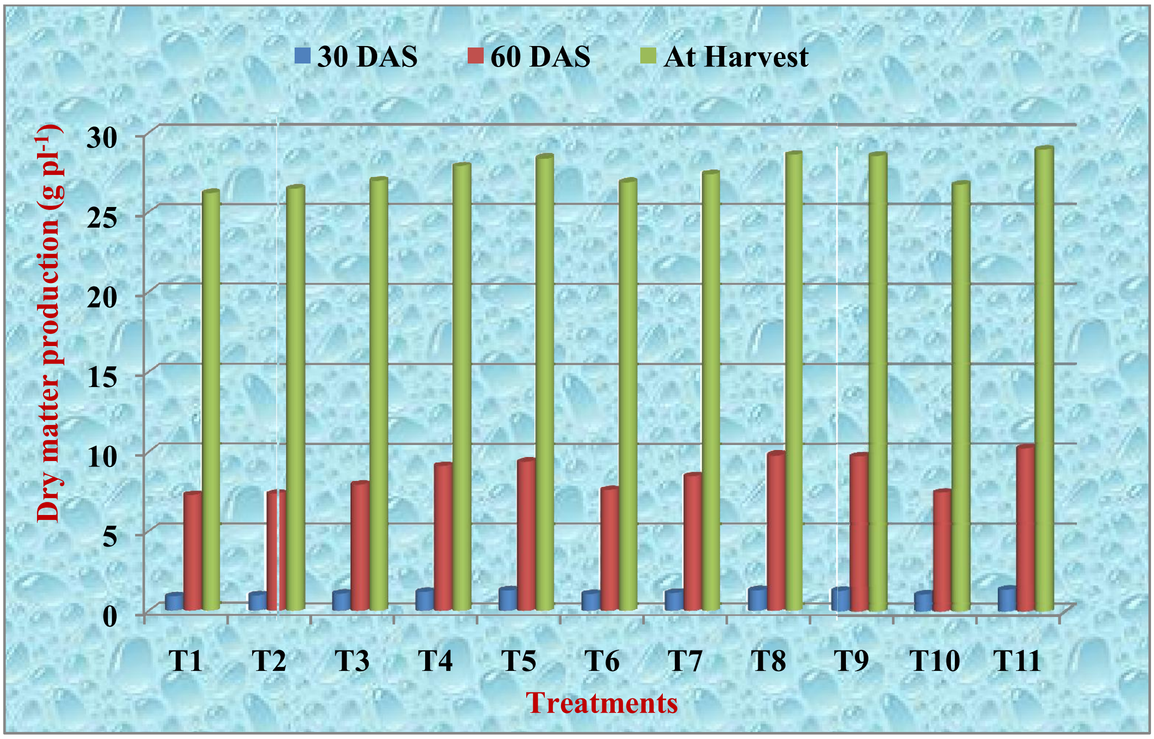

Fig 4: Dry matter accumulation in crop at different growth stages of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

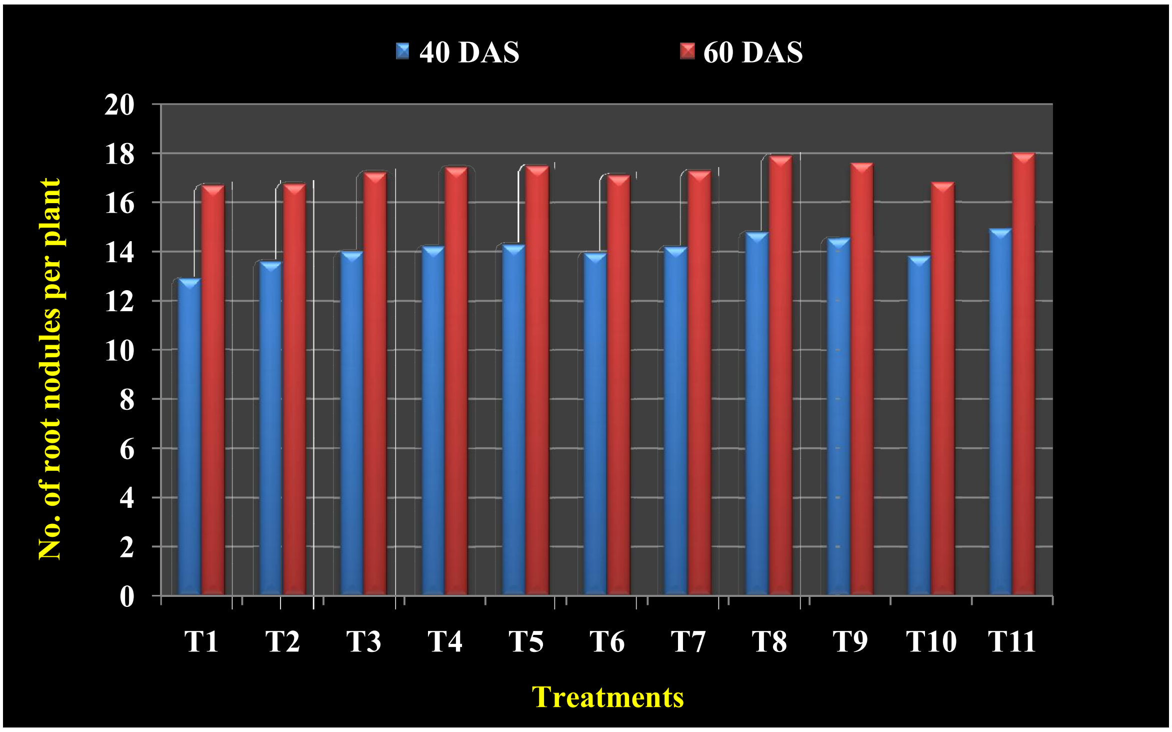

Fig.5: Number of root nodules per plant at different growth stages of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

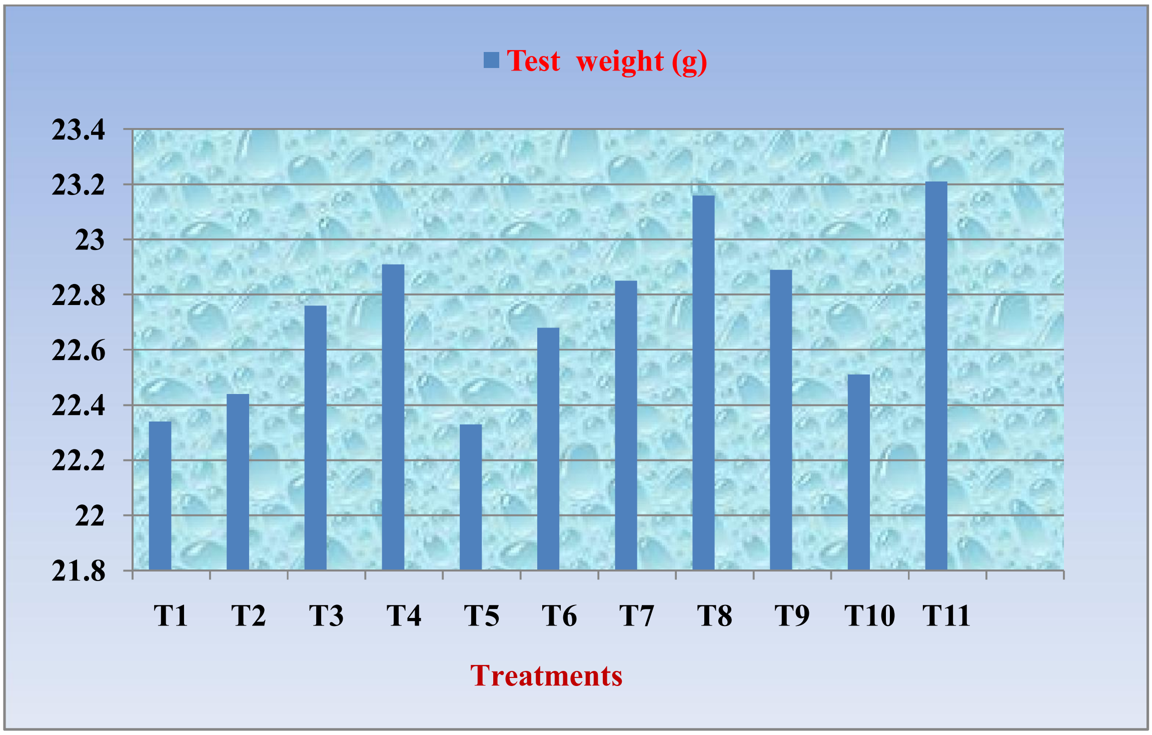

Fig.6: Test weight (100 seed weight) of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

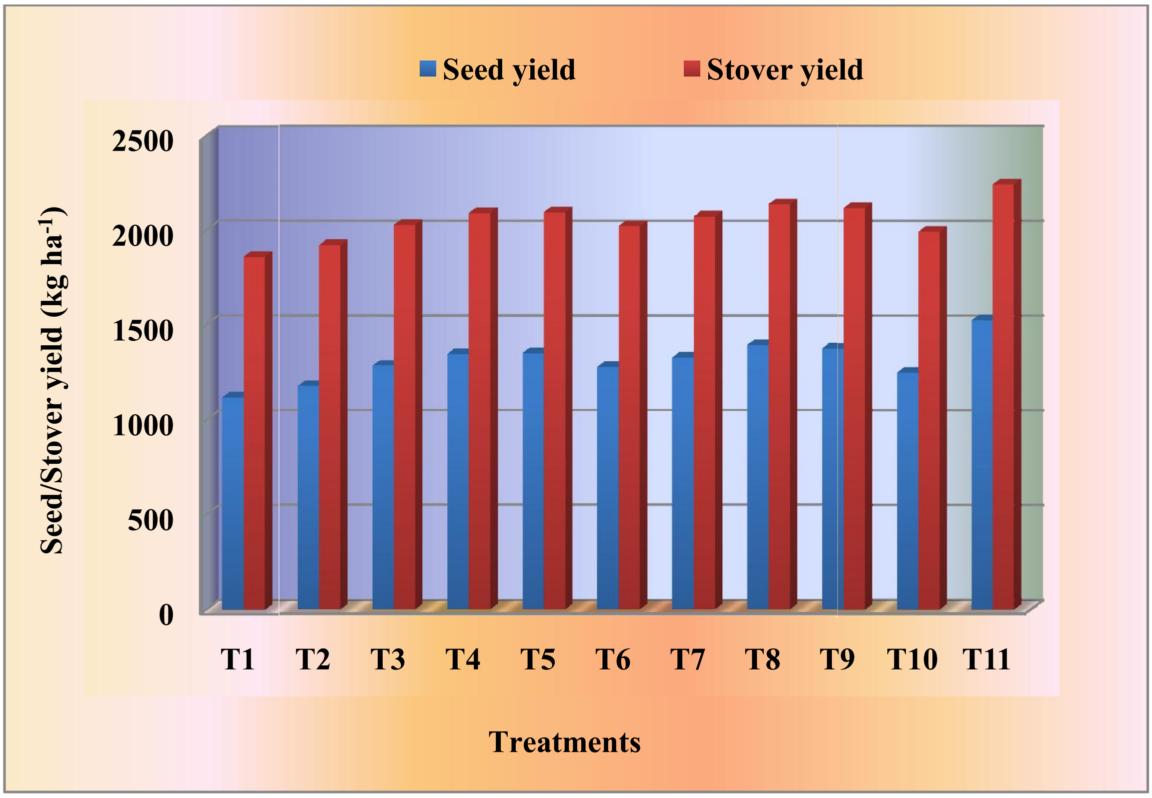

Fig.7: Yield attributes of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

nutrients and increased nitrogen from organic manure (FYM+VC+LF) which has profound influence in mobilizing the nutrients from the unavailable forms of nutrients mainly due to the improved the physical, chemical and biological properties of the soil. Similarly, reported by Jayabharth Reddy (2000). The present findings are also in consonance with the findings of Ravikumar and Krishnakumar (1980), Maskina *et al.* (1985) and Ferias *et al.* (1986).

This has clearly indicated the need for adding organic manures to the soil in which increases the availability of nutrients considerably resulting in positive effect on soybean yield.

The difference in the seed yield was largely because of variations in yield components such as number of pods plant^{-1}, seed yield plant^{-1} and test weight. It might be due to higher yield components that are directly responsible for seed yield appeared to be determined by physiological characters both during vegetative and reproductive phases of the crop growth. The results of this investigation agree with the findings of Tomar *et al*. (2000).

5.3. Nutrient content and total uptake

5.3.1. Nitrogen

The data on nutrient content in seed and straw significantly differed with the application of sources of organic and inorganic on chickpea are presented in Table 11 to 15.

Application of sources of organic and inorganic influenced the nitrogen content in seed, haulm and total uptake in chickpea crop. The higher nitrogen content in seed, straw and total uptake was found in application of (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. It was superior over all other treatments. Higher nitrogen uptake was due to higher mineralization of nitrogen from applied organic source. The results of present investigation are in conformity with Tiwari (2007), Singh *et al*. (2006), Tolessa Debele *et al*. (2001). Similarly, Ganeshappa (2000) reported that, uptake and availability of nutrients *i.e*., N, P and K were significantly higher due to the application of vermicompost.

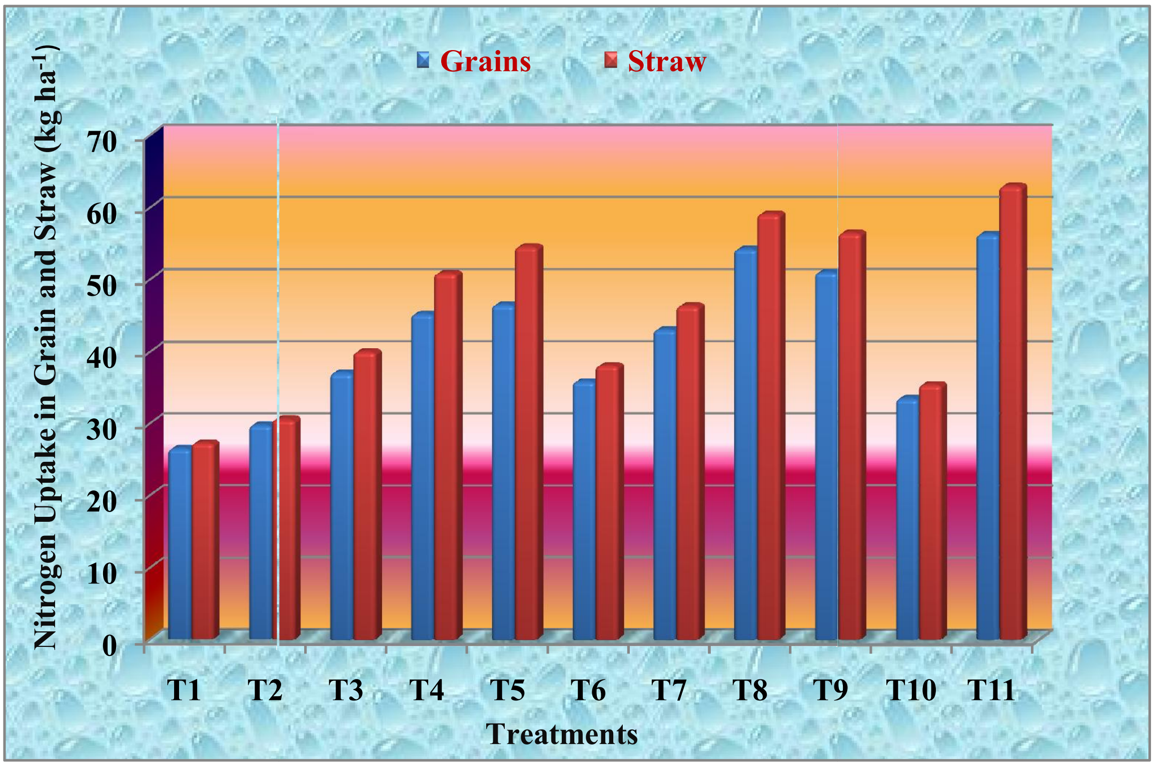

Fig.8: Nitrogen uptake on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

5.3.2. Phosphorus

The phosphorus content in seed, haulm and total uptake increased significantly with increase with application of organic sources. The higher phosphorus content in seed, straw and total uptake was recorded in (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. It was superior over (T_8) VC @ 2.5 t ha^{-1} + 100% RDF. However, lowest phosphorus content in seed, straw and total uptake was noticed in the T_1 (RDF alone) treatment. Higher phosphorus uptake was due to higher P application through inorganic fertilizer and organic source, this has created surplus P in the soil. The mineralization of this organic source in addition to soil had provided ample opportunity for plants to uptake this element in addition to fixation that normally takes place. Vermicompost, farm yard manure and jeevamrutha application reduced the loss of nutrients through leaching and made available to plant which created a balancing effect on supply of nitrogen, phosphorus and potassium. These results are in support with the findings of (Vijayapriya *et al*. 2005).

5.3.3 Potassium

The potassium concentration in seed, straw and total uptake increased significantly with application of organic sources. The highest potassium content in seed, straw and total uptake was recorded in T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevam rutha. It was superior over (T_8) VC @ 2.5 t ha^{-1} + 100% RDF. However, lowest potassium content in seed, straw and total uptake was noticed in the T_1 (RDF alone) treatment. It might be due to direct addition of nutrients through Vermicompost, farm yard manure and jeevamrutha and it might have improved availability of native soil nutrients and their uptake by chickpea crop. The results of this investigationare agree with the findings of Gopal Reddy. (1997).

5.3.4. Sulphur

The treatment receiving at (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1}+ Jeevamrutha. was recorded significantly higher sulphur concentration in seed, straw and total uptake over the application of over (T_8) VC @ 2.5 t ha^{-1} + 100% RDF. However, lowest sulphur content in seed, straw and total uptake was noticed in the T_1 (RDF alone) treatment. It

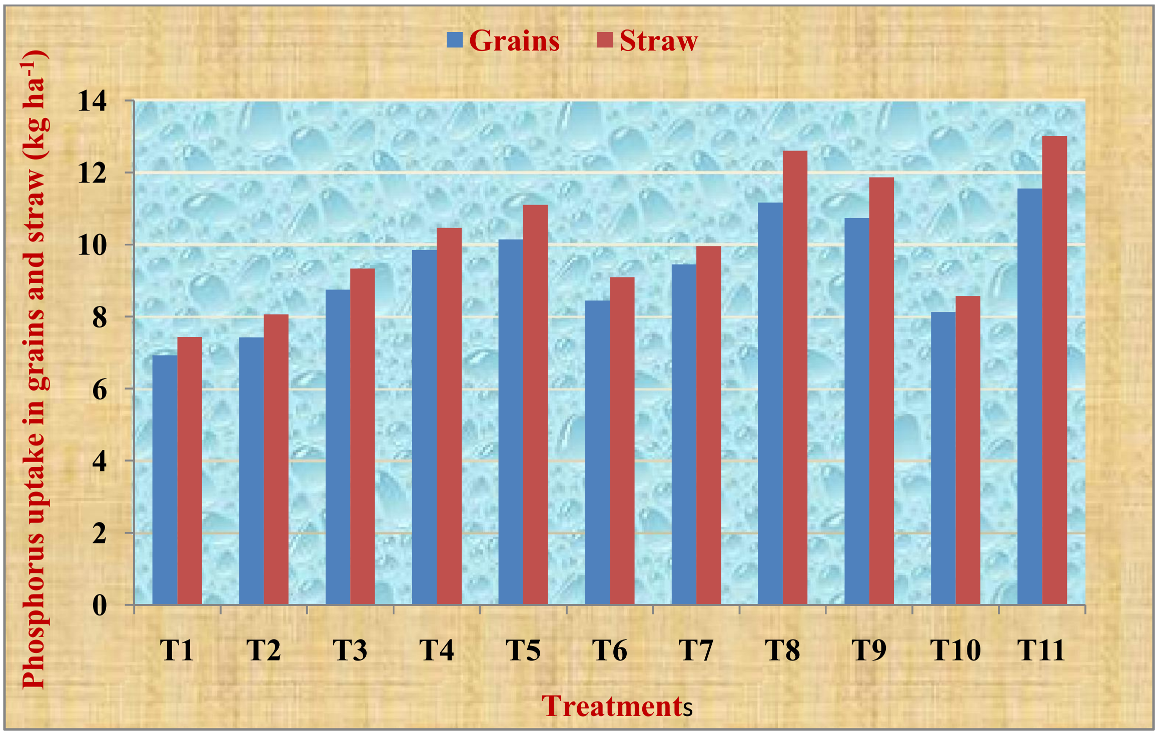

Fig.9: Phosphorus uptake on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

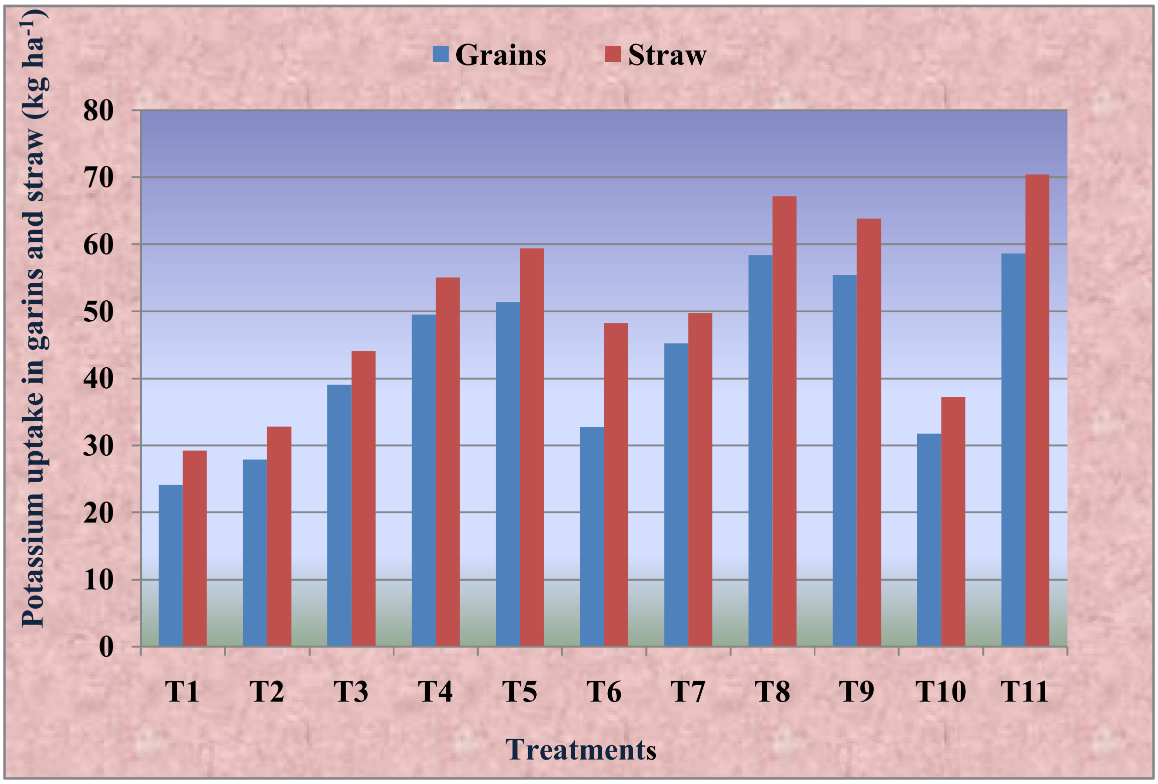

Fig.10: Potassium uptake on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

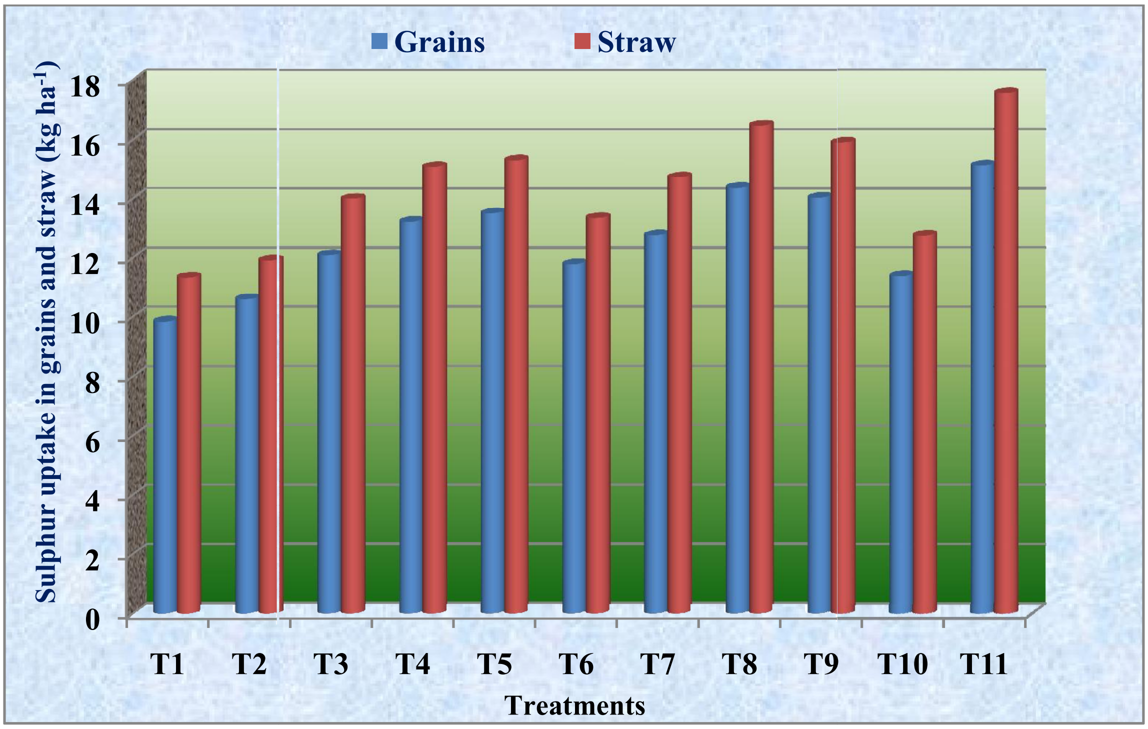

Fig.11: Sulphur uptake on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

might be due to application of vermicompost, farm yard manure and jeevamrutha resulted in increased the uptake of sulphur. Similar results were found in Ganeshmurthy (1996).

5.3.5 Micronutrients

5.3.5.1. Zinc, Iron, Manganese, Copper and Boron

Iron, Manganese, zinc, boron and copper content and uptake of these micro nutrients was significantly increased with application of organic manures. The treatment receiving at (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha was recorded higher iron, manganese, zinc, boron and copper concentration in seed, straw and total uptake over the application (T_8) VC @ 2.5 t ha^{-1} + 100% RDF. However, lowest sulphur content in seed, straw and total uptake was noticed in the T_1 (RDF alone) treatment. It might be due to microbial decomposition of organic manures with simultaneous release of organic acid might have favoured the availability of micronutrients in soil and their uptake by chickpea. This may be due to faster the decomposition of organic manures as results of narrowing of C:N ratio with the application of organic sources. These results are in support with the findings of Sakal *et al.* (1993).

Addition of organic manures to soil besides increasing the availability of micronutrients in soil, the complexing properties of these manure with micronutrients might have prevent the precipitation, fixation, leaching and kept them in soluble form which might have resulted in higher uptake of these micronutrients by soybean crop. Similar results were reported by Ghosh *et al.* (1999).

5.4. Available nutrients in soil as influenced by integrated nutrient management practices

The data on available status of major, secondary and micronutrients as affected by application of organic manures after the harvest of the crop presented in Table 10, 16 & 17.

5.4.1 Soil pH

There was no significant difference in the soil pH due to application of organic sources. Soil pH has slightly decrease after harvest of chickpea crop compare to initial

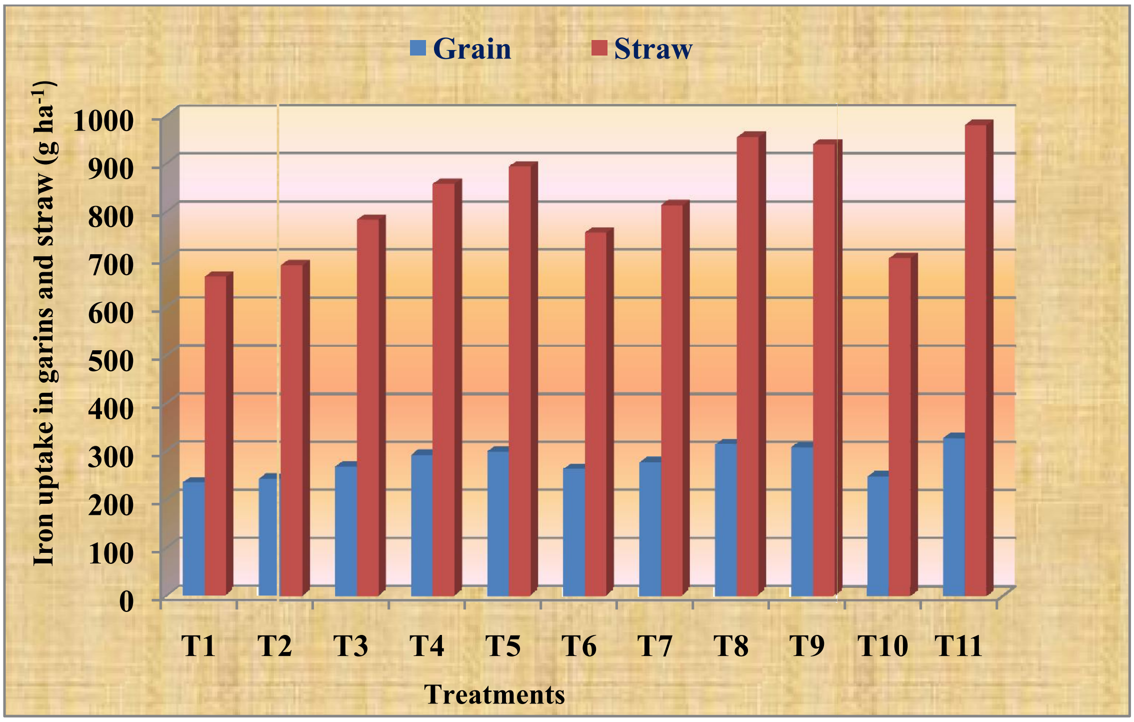

Fig.12: Iron uptake on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

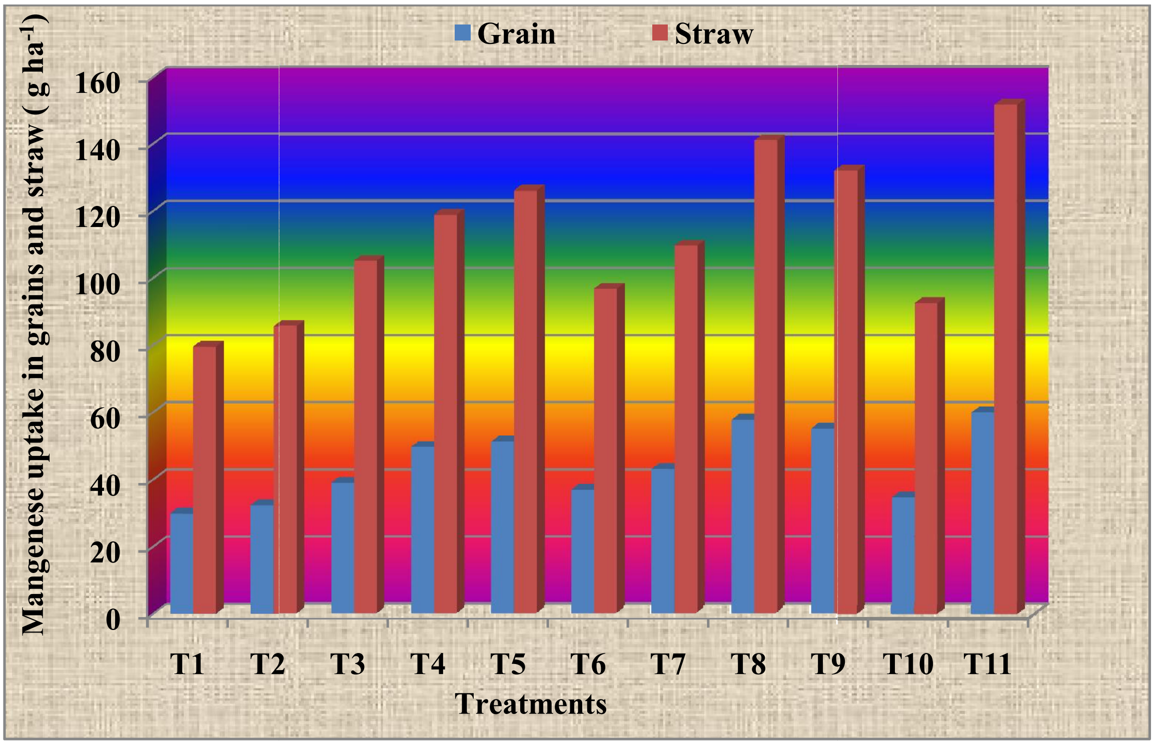

Fig.13: Mangenese uptake on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

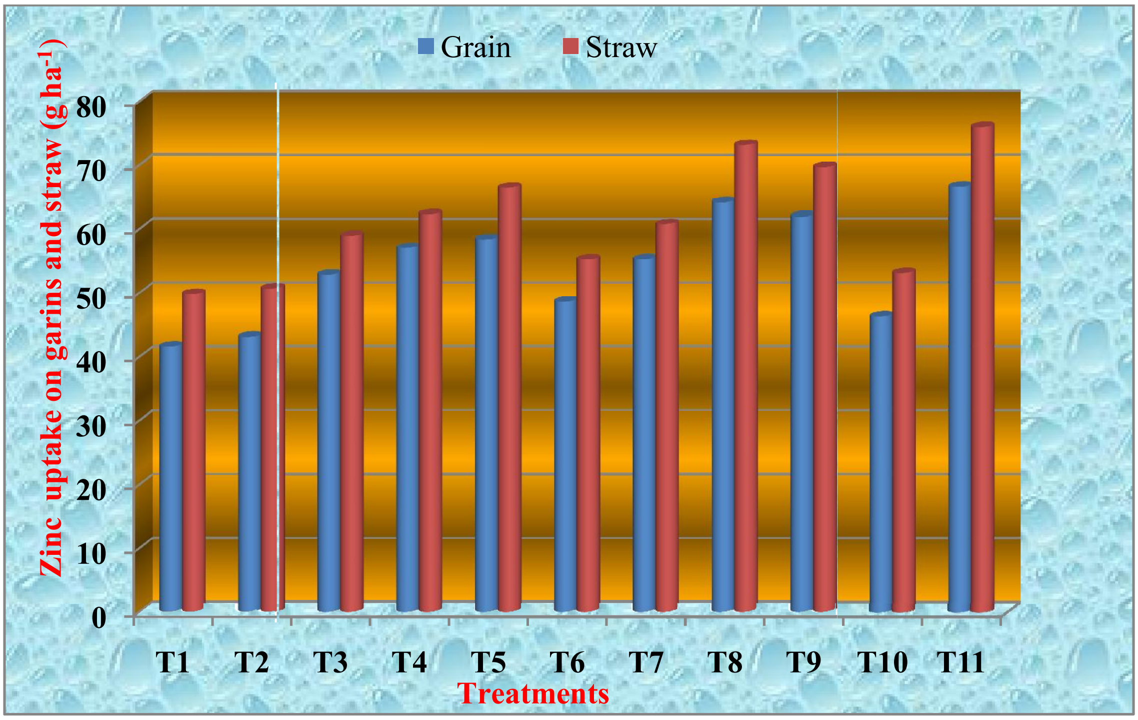

Fig.14: Uptake of zinc on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

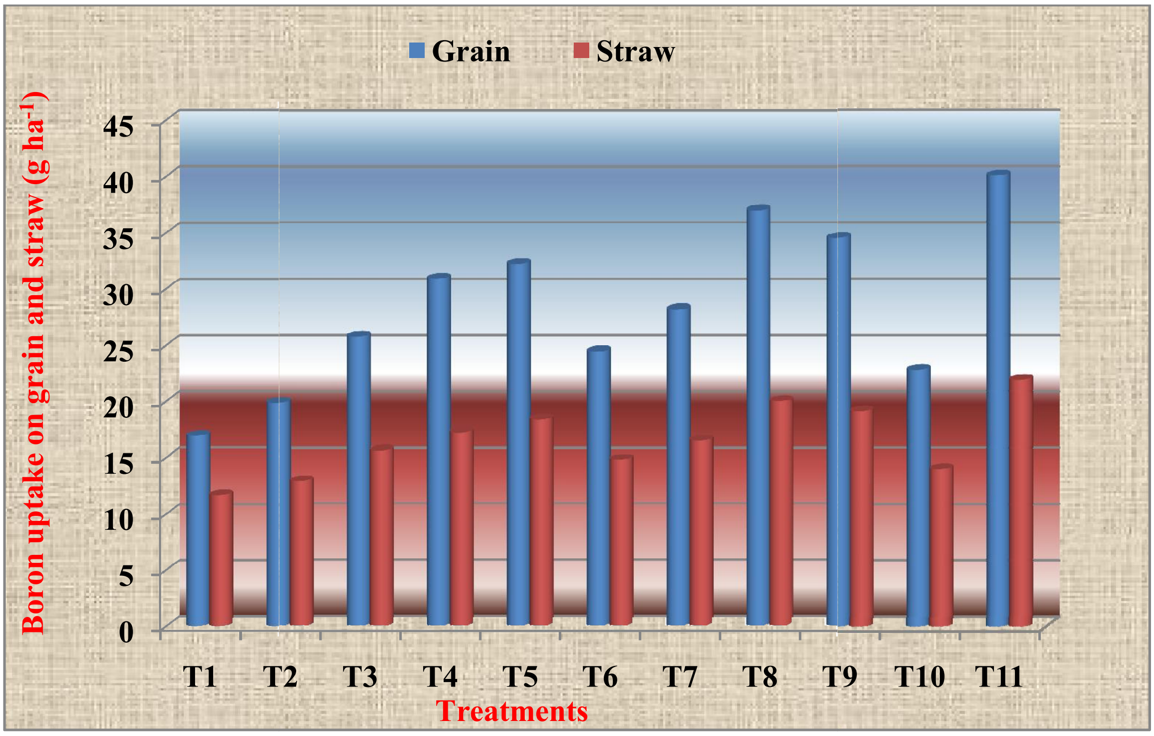

Fig.15: Uptake of boron on grain and straw of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 $N:P_2O_5:K_2O$ kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

pH value (8.20). The decrease in soil pH might be attributed to the release of organic acids during the microbial decomposition of added organic manures and increased the enzymatic activity in soil. These results are in conformity with those reported by Babu and Reddy (2000), stated that addition of vermicompost increases soil pH initially and decreases in the later stage due to release of organic acids during decomposition.

5.4.2 Electrical conductivity

Data pertaining to EC did not show significant difference due to integrated nutrient management practices.

Lower EC was recorded in the (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha and the highest EC was recorded with application of T_1 (RDF alone). EC of soil did not vary much due to incorporation of different organic manures and the results are in conformity with the findings of Amjad Ali *et al*. (2011).

5.4.3 Organic Carbon

The organic carbon content of soil not differs significantly due to application of organic manures application.

Higher organic carbon content was recorded in the treatment (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. However, least organic carbon content was recorded in the T_1 (RDF + FYM). This might be due to build-up of higher amount of organic carbon in soil after harvest of crop which is due to addition of higher biomass to soil through vermicompost, farm yard manure and jeevamrutha. Similar results were obtained by Amjad Ali *et al.* (2011).

5.4.4 Available nitrogen

The available nitrogen content of soil differs significantly due to application of organic manures. Highest available nitrogen was recorded in (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha and lowest available nitrogen was recorded with application of T_1 (RDF alone). It might be due to application of organic manures its helps to increase available nitrogen in soil, which may be attributed to mineralization of nitrogen from vermicompost and farm yard manure and jeevamrutha during decomposition. And also due to addition of vermicompost contained higher amount of nitrogen and considerable amount of nitrogen was in uric acid form which is readily available sources of nitrogen and C:N ratio of vermicompost narrow than FYM which accentuates the release of nitrogen in soil and thus contributing the available pools of nitrogen. Similar, results were obtained by Singh *et al.* (2000), Chadwick *et al.* (2000) and Dosani *et al.* (1999).

5.3.5 Available phosphorus

The available phosphorus status of soil was significantly affected by the sulphur and organic manures application. Highest phosphorus was recorded in the (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. It might be due to the Organic manures, on decomposition, solubilize insoluble organic P fractions through release of organic acids, thus resulting significant improvement in soil available P status due to application of vermicompost, farm yard manure and jeevamrutha. Similar, results are in conformity with the findings of (Sharma *et al.,* 2013), Shivakumar and Ahlawat (2008) and Chitdeshwari *et al.* (1997).

5.3.6 Available potassium

The available potassium status in soil was significantly affected by organic manures. The highest available potassium recorded in the (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. However lowest potassium content was noticed in the (T_1) 100 % RDF alone. Higher availability of potassium might be due to the build-up of available potassium in soil was due to beneficial effect of organic manures in releasing potassium due to the interaction of organic manure with clay and direct addition of potassium to the available pools of soil. The results are in conformity with the findings of Madhavi and Suryanaraya Reddy. (1994) and Sharma and Gupta (1992).

5.4.7 Available sulphur

The application of organic sources had significantly increased the sulphur status of soil. It is quite obvious that addition of vermicompost increased the S status of soil. Among the different treatments significantly higher available sulphur was found in the (T_{11}) FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. The increase available sulphur due to organic manure application might be due to its direct addition through organic manures and mineralization of sulphur due to decomposition of organic matter. The

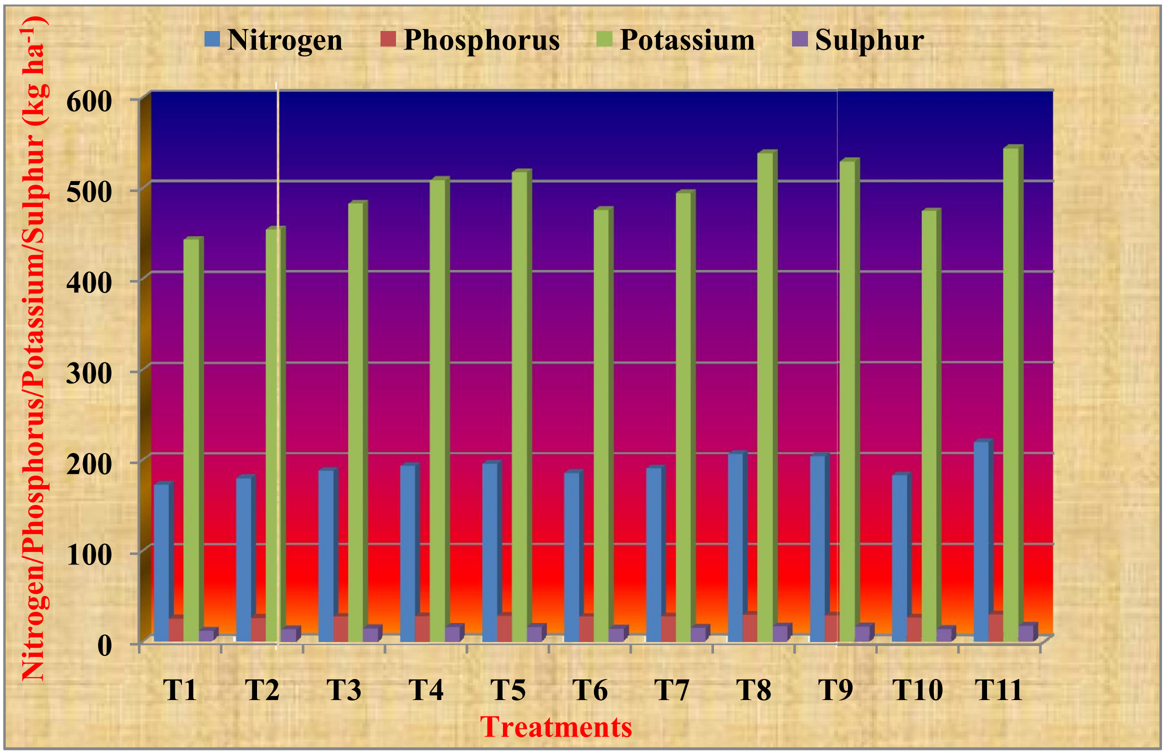

Fig.16: Available nutrients of Nitrogen, Phosphorus, Potassium and Sulphur on soil after the harvest of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

similar results were reported by Ramnathan and Ramnathan (1985), Singh *et al*. (1988).

5.4.8 Available micronutrients

Available micronutrients content increased by application of different levels of sulphur and organic manures in the soil. Higher available micronutrients was found in (T_{11}) which was receiving FYM @ 5 t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha. The increase available micronutrients status of soil and release of chelating agents which might have prevented micronutrients from precipitation, oxidation and leaching. Results of the present study are in conformity with the findings of Sharif *et al*. (2002).

The availability of Fe, however, seems to be higher than that of Zn, Mn, B and Cu. This can be due to the fact that Fe forms metallo-organic complex of higher stability then that of Zn, Mn, B and Cu. These results are in conformity with the findings of Kher (1993).

5.5 The effect of organic and inorganic sources of nutrients on soil microbial population.

5.5.1 Soil microbial population

The essence of practicing organic farming lies in the use of naturally available resources like organics, natural processes like decomposition biological nitrogen fixation and resistance to achieve the needs of crop production. Applying organic manures for growth of the crop, which inturn improves the organic matter status of soil. Organic manures not only helps to supply the nutrients but also acts as a food for microorganisms and encourage the multiplication of their counts, which inturn improves the mineralization of nutrients in soil and thus, fertility and productivity of the soil is improved. The enhancement of soil microbial counts is known to influence crop productivity. In the present study, significant improvement in the soil microorganisms *viz*., bacteria, fungi and actinomycetes noticed at harvest stages of chickpea (Table 18). The significant increase in microbial counts was observed with the addition of organic manures in combination with fermented liquid organic manure. Application of FYM + VC + Jeevamrutha, VC + Jeevamrutha and VC + 100% RDF recorded significantly higher bacterial, fungal and actinomycetes population at harvest. This could be due to

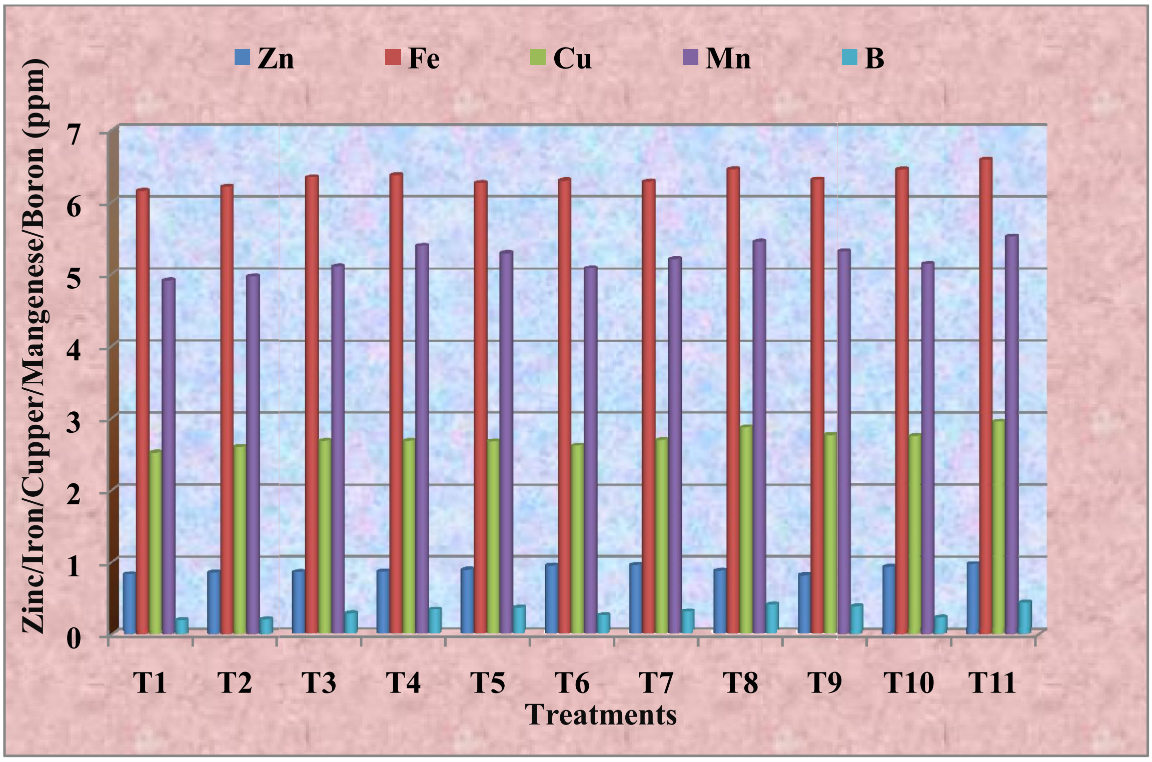

Fig.17: Available micronutrients on soil after the harvest of chickpea as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

cumulative effect of various sources of organic manures in increasing organic carbon content of soil which acted as carbon and energy source for microbes and their quick build up in the soil (Barik *et al*., 2006 and Palekar, 2006). Lower bacterial, fungal and actinomycetes population was noticed in RDF treatment. Because it did not cause significant changes in the soil microbial population, growth and functioning of soil microbial counts as carbon substrate availability is limited. These results are in line with the findings of Sreenivasa, 2007; Deshpande *et al.,* 2010; Anonymous, 2011; Dhok and Ghodpage, 2011 and Sharada 2013. Who reported higher soil microbial population with addition of combined application of organics.

5.5.2 Dehydrogenase activity

The dehydrogenase activity in soil was influenced significantly due to application of organic manures in chickpea crop (Table 18) at harvest. significantly higher dehydrogenase activity was recorded in T_{11} which received FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha (13.11) and was on par with T_8 VC @ 2.5 t ha^{-1} + 100% RDF (12.86), VC @ 2.5 t ha^{-1} + Jeevamrutha (12.61). However, significantly lower dehydrogenase activity was recorded with RDF alone treatment (7.17). This might be due to the presence of substrate through organic manures like FYM, vermicompost and jeevamrutha etc. and increased buildup in the microbial population resulting in the dehydrogenase enzyme activity in soil (Gayatri Verma and Mathur, 2009). Also might be ascribed to the increased microbial activity as a result of increased availability of substrate namely organic carbon through organic manures causing biological explosion (increase in microbial population) which in turn might have released enzymes of extracellular origin. Similar results were observed by Kanwar *et al*. (2006).

5.6 The effect of organic and inorganic sources of nutrients on economics of chickpea cultivation (cf. Table 19)

Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher B: C ratio (2.16) as compared to all other treatments, and lower B: C ratio (1.89) with rest of the treatments. It could due to the higher the yield obtained than the RDF treatment.

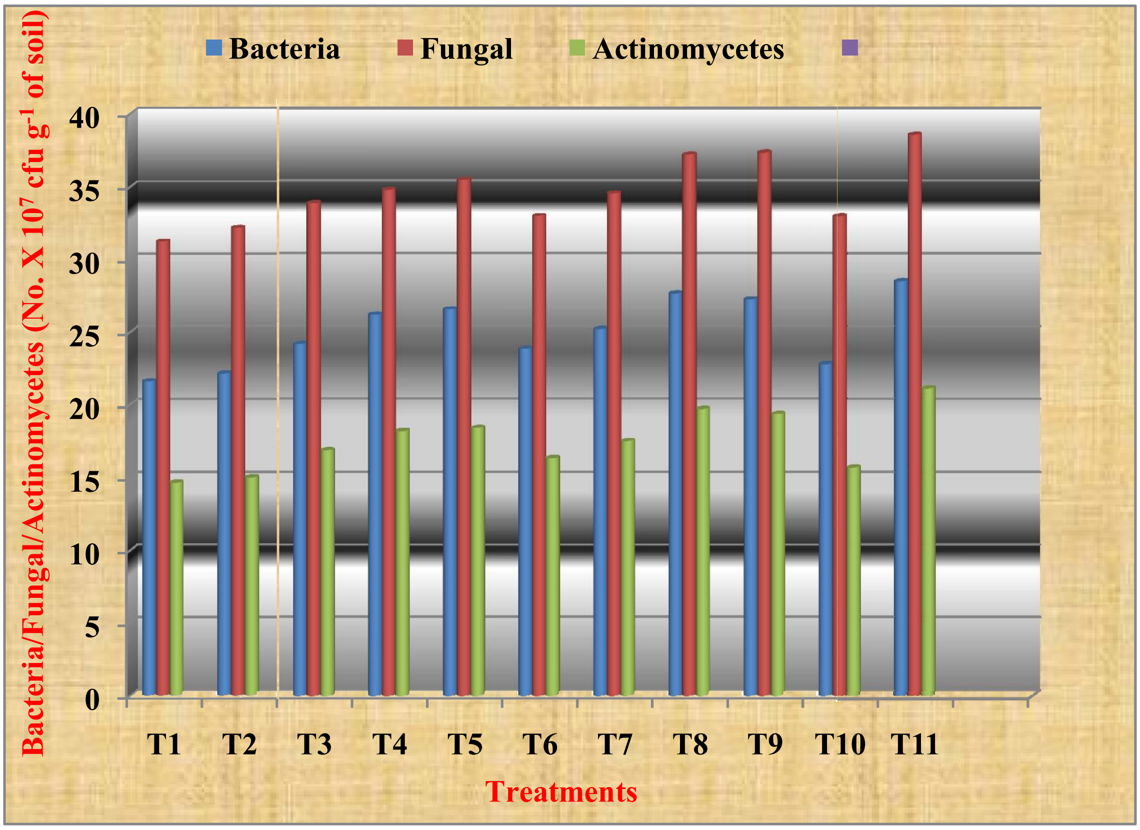

Fig.18: Soil microbial biomass of soil after harvest of the crop as influenced by nutrient management practices.

Treatment details

T_1: RDF(10:25:0 N:P_2O_5:K_2O kg ha^{-1})

T_2: FYM @ 5 t ha^{-1} + 50% RDF

T_3: FYM @ 5 t ha^{-1} + 75% RDF

T_4: FYM @ 5 t ha^{-1} + 100% RDF

T_5: FYM @ 5 t ha^{-1}+ Jeevamrutha

T_6: VC @ 2.5 t ha^{-1} + 50% RDF

T_7: VC @ 2.5 t ha^{-1} + 75% RDF

T_8: VC @ 2.5 t ha^{-1} + 100% RDF

T_9: VC @ 2.5 t ha^{-1}+ Jeevamrutha

T_{10}: RDF + Jeevamrutha

T_{11}: FYM @ 5t ha^{-1} + VC @ 2.5t ha^{-1} + Jeevamrutha

VI. SUMMARY AND CONCLUSION

A field experiment was conducted at Krishi Vignana Kendra, Kalaburagi, University of Agricultural Sciences, Raichur, conducted during *rabi* 2015-16. To study the “Nutrient management in chickpea (*Cicer arietinum* L.) in black soil under rainfed situation”. The experiment consisted of eleven treatments comprised of RDF alone, in combination of FYM @ 5 t ha^{-1} with (50%, 75%, 100% RDF and Jeevamrutha), vermicompost @ 2.5 t ha^{-1} with (50%, 75%, and 100% RDF and Jeevamrutha), FYM @ 5 t ha^{-1} + vermicompost @ 2.5 t ha^{-1} + Jeevamrutha and RDF + Jeevamrutha. The trial was laid out in randomized complete block design with three replications. The elite findings of investigation are summarized below.

Plant was differed significantly at different growth stages (30, 60 DAS and at harvest) of chickpea. Plant height was significantly higher with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha at all the growth stages of chickpea. Whereas, significantly lower plant height was recorded with application of RDF (control).

Number of branches per plant was differed significantly at different growth stages (30, 60 DAS and at harvest) of chickpea, significantly higher branches in the treatment receiving FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. Whereas, significantly lower number of branches per plant was recorded with the application of RDF (control).

Dry matter accumulation per plant in different parts of chickpea were significantly influenced by nutrient management at all stages of crop growth. Dry matter production per plant was significantly higher with RDF application which was superior over rest of the treatments at 30 DAS. Application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha recorded significantly higher dry matter production. Significantly lower dry matter production per plant was noticed in application of RDF (control).

Number of root nodules per plant at 40 DAS and 60 DAS was significantly higher in treatment FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. Significantly lower number of root nodules per plant was noticed in RDF treatment.

Yield parameters like number of pods per plant were significantly higher with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha, closely followed by VC @ 2.5 t ha^{-1} +

100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and FYM @ 5 t ha^{-1} + Jeevamrutha. Significantly lower number of pods per plant was noticed in application of RDF alone.

Test weight did not differ significantly however, FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha application recorded higher test weight followed by followed by VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and RDF treated plot was recorded lower test weight.

Seed yield was significantly higher with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha over rest of the treatment except VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and FYM @ 5 t ha^{-1} + Jeevamrutha. Significantly lower seed yield was recorded in RDF treatment.

Stover yield was significantly higher with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha received plot which closely with treatments *viz*., VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and FYM @ 5 t ha^{-1} + Jeevamrutha. Whereas, significantly lower stover yield was recorded with RDF application.

Total uptake of major nutrients like nitrogen, phosphorous, potassium, and sulpur of chickpea was significantly increased by the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha followed by the treatments like VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and FYM @ 5 t ha^{-1} + Jeevamrutha. Significantly lower uptake of nitrogen, phosphorous, potassium, and sulpur of chickpea was recorded in RDF treatment.

Total uptake of micro nutrients like Zinc, Iron, Cupper, Manganeese, and Boron of chickpea was significantly increased by the application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha followed by the treatments like VC @ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and FYM @ 5 t ha^{-1} + Jeevamrutha. Significantly lower uptake of Zinc, Iron, Cupper, Manganeese, and Boron of chickpea was recorded in RDF treatment.

Soil physic-chemical properties *viz*., p^{H}, EC, OC did not differ significantly, whereas available major and micro nutrients in soil after harvest of chickpea was significantly higher in FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha followed by VC

@ 2.5 t ha^{-1} + 100% RDF, VC @ 2.5 t ha^{-1} + Jeevamrutha and FYM @ 5 t ha^{-1} + Jeevamrutha. Significantly lower values of major and micro nutrients were noticed with RDF treatment.

Soil biological properties *viz*., bacteria, fungi and actinomycetes biomass count at harvest of chickpea was significantly higher with FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha, VC @ 2.5 t ha^{-1} + 100% RDF and VC @ 2.5 t ha^{-1} + Jeevamrutha over rest of the treatments when compared to their initial values before sowing. Significantly lower microbial population was observed with RDF treatment.

Conclusion:

From the results of the present study, it can be concluded that there was significant response of nutrient management on chickpea crop through combined application of organic manures along with liquid organic *viz.,* jeevamrutha. Application of FYM along with vermicompost and jeevamrutha could be the best nutrient combination for enhancing the growth, yield, nutrient uptake, availability and microbial biomass of chickpea because of slow release of nutrients at all the stages of crop growth, which has profound influence in mobilizing the nutrients from unavailable to available form and also reduces the loss of nutrients through leaching and volatilization.

Future line of work:

Research work on effect of graded levels of sulphur and organic manure on chickpea should be carried out in Northern Karnataka under different agro-climatic conditions.

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APPENDIX – I

Prices of inputs and output

Sl. No.	Particulars	Prices (Rs.)
I. Inputs		
1.	Chickpea seeds (JG-11)	70 kg^{-1}
2.	FYM	500 t^{-1}
3.	Vermicompost	3500 t^{-1}
4.	Jeevamrutha	90 l^{-1}
5.	Fertilizer	
	a) Urea	1,072 q^{-1}
	b) Diammonium phosphate (DAP)	2,600 q^{-1}
6.	Labour wages	
	a) Labour	200 day^{-1}
	b) Bullock pair with men	800 day^{-1}
II. Output		
	a) Chickpea seeds	4,400 q^{-1}

APPENDIX – II

Nutrient status of FYM, VC and JEEVAMRUTHA used in the experiment.

Nutrients (%)	Farm Yard Manure	Vermicompost	Jeevamrutha
Nitrogen	1.50	3.20	1.4
Phosphorus	0.20	0.85	0.104
Potassium	0.50	0.85	0.084
Sulphur	0.68	0.60	0.032

NUTRIENT MANAGEMENT IN CHICKPEA (*Cicer arietinum* L.) IN BLACK SOIL UNDER RAINFED SITUATION

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Abstract: A field experiment was conducted at KVK, Kalaburagi during *rabi,* 2016-17 to study the effect of nutrient management in chickpea under black soil rainfed situation. Among all the treatments, application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha significantly recorded higher plant height (26.70, 40.93, 44.68), branches $plant^{-1}$ (4.83, 6.80, 8.40), DMP (1.36, 10.20, 28.90) at 30, 60 DAS and harvest, root nodules $plant^{-1}$ (14.83, 18) at 40 and 60 DAS, Seed and Stover yield (1525.67 kg ha^{-1} and 2243 kg ha^{-1}) over rest of the treatments because application of organic manures in combination with inorganic fertilizers to the soil, resulted in increased and steady availability of nutrients, from organic manure (FYM+VC+LF) which had influenced in mobilizing the nutrients from the unavailable to available forms. Soil physico-chemical properties *viz*., p^H, EC, OC did not differ significantly, whereas uptake and availability of N (119.11 kg ha^{-1} and 219.52 kg ha^{-1}), P_2O_5 (24.56 kg ha^{-1} and 29.57 kg ha^{-1}), K_2O (129.07 kg ha^{-1} and 543.20 kg ha^{-1}) and S (32.67 kg ha^{-1} and 17.06 kg ha^{-1}) were recorded significantly higher in the treatment with application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha. It is concluded that the application of application of FYM @ 5 t ha^{-1} + VC @ 2.5 t ha^{-1} + Jeevamrutha was found best combination for higher chickpea crop yields compared to other of treatments.