

**STUDIES ON GROWTH, YIELD AND QUALITY OF TULSI
(*Ocimum sanctum* L.) AS INFLUENCED BY ORGANIC
MANURES**

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**STUDIES ON GROWTH, YIELD AND QUALITY OF TULSI
(*Ocimum sanctum* L.) AS INFLUENCED BY ORGANIC
MANURES**

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by

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CERTIFICATE

This is to certify that the thesis entitled “**STUDIES ON GROWTH, YIELD AND QUALITY OF TULSI (*Ocimum sanctum* L.) AS INFLUENCED BY ORGANIC MANURES**” submitted by **Mr. SACHINKUMAR BELERI** for the degree of **MASTER OF SCIENCE (AGRICULTURE)** in **HORTICULTURE** College of Agriculture, Raichur, University of Agricultural Sciences, Raichur is a record of research work carried out 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 of the award of any degree, diploma, associateship, fellowship or other similar titles.

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Affectionately dedicated

to my beloved parents

Shri. Sidramappa, Smt. Saroja

Shri. Subhashchandra, Smt. Girija

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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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(SACHINKUMAR BELERI)

LIST OF ABBREVIATION

Abbreviation	Expansion
%	: Per cent
@	: At the rate of
Anon,	: Anonymous
B: C	: Benefit Cost Ratio
C.D	: Critical Difference
cm	: Centimeter
DAT	: Days after transplanting
<i>et al.</i>	: and co-workers
Fig.	: Figure
FYM	: Farmyard Manure
g	: Gram
ha	: Hectare
kg	: Kilogram
LAI	: Leaf Area Index
L	: Liter
m	: Meter
wt	: Weight
ml	: Milliliter
NS	: Non Significant
°C	: Degree Celsius
S. Em	: Standard Error Mean
t	: Ton
t ha ⁻¹	: Tons per hectare
<i>viz.,</i>	: Namely
<i>i.e.</i>	: That is
Rs.	: Rupees
/	: Per
T	: Treatment
etc.	: Etcetera

no.	:	Number
±	:	Positive negative
RBD	:	Randomized Block Design
RH	:	Relative Humidity
Fe	:	Iron
Mn	:	Manganese
Cu	:	Copper
Zn	:	Zinc
Ca	:	Calcium
Mg	:	Magnesium
S	:	Sulphur
ppm	:	Parts Per Million
µg	:	Microgram
kg ha ⁻¹	:	Kilogram per hectare
cm ²	:	Centimeter square
q ha ⁻¹	:	Quintal per hectare
mg	:	milligrams
RDN	:	Recomemded Dose of Nitrogen
g plant ⁻¹	:	Grams per plant
m ⁻³	:	Per meter cube
m ²	:	Meter Square
pH	:	Potential of Hydrogen
g/cc	:	Grams per cubic centimeter
cm ² plant ⁻¹	:	Centimeter square per plant
V	:	Variety
N-S	:	North-South
E-W	:	East-West

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Introduction

I. INTRODUCTION

Tulsi/Sacred basil/Holy basil (*Ocimum sanctum* L.; $2n = 32$) is one of the holiest and most cherished among the many healing and health-giving herbs of the orient. Tulsi is a biennial or triennial aromatic shrub belonging to the family Lamiaceae. This shrub is a native to tropical Asia, likely to have originated in India. It is also called by other names like “the Incomparable one, mother of natural medicine and the queen of herbs.” Tulsi is renowned for its religious and spiritual sanctity, as well as for its important role in the traditional ayurvedic and unani systems of medicine. Medical, religious and culinary use of tulsi has also been documented for centuries in China, the Middle East, North Africa and Australia. It is also mentioned by Charaka in the “Charaka Samhita” - An ayurvedic epic.

Tulsi is naturally found in wild habitats of tropical and subtropical regions of the world. It can be grown all over India, up to a height of 2000 meters above mean sea level. It is grown in houses, temples and gardens. The main centers of diversity in this species are in Africa, South America (Brazil) and Asia. Tulsi is also found growing in France, Italy, Bulgaria, Egypt, Hungary, South America, Comoro Islands, Thailand, Haiti and Guatemala. In India, the cultivation of tulsi is mainly concentrated in Uttar Pradesh, Assam, Bihar, Maharashtra, Madhya Pradesh, West Bengal and Haryana (Rao *et al.*, 2007). In Karnataka, tulsi is cultivated in an area of 316 hectares in Ballari, Chamarajanagara, Ramanagara, Davanagere and Gadag districts with a production of 2862 Metric Tons (Anon., 2019).

Tulsi is an erect aromatic shrub that grows to a height of 0.5-1.5 meters and has red or purple or green quadrangular branches. The leaves are opposite, about 2-4 centimeters long, margins entire or toothed, hairy on both the surfaces, dotted with minute glands and are aromatic. The flowers are tiny, purple and inflorescence is a long spike of 12-14 centimeters in length. The fruits are small, smooth nutlets and reddish grey in color (Krishna *et al.*, 2014). The genus *Ocimum* contains 160 species some of which *Ocimum sanctum*, *Ocimum gratissimum*, *Ocimum canum*, *Ocimum basilicum*, *Ocimum kilimandschricum*, *Ocimum amaricanum*, *Ocimum camphora* and *Ocimum micranthum* are important (Summy and Patyal, 2016). In India, two types of *Ocimum sanctum* are under cultivation *i.e.* Rama tulsi or Sri tulsi, which bears green leaves and Krishna tulsi or Shyama tulsi, which bears purple leaves. Rama tulsi is the most common type which is

grown in pots in most of the traditional Hindu households. Krishna tulsi is preferred in trade for its higher medicinal potency.

Tulsi has a variety of biological or pharmacological activities such as anti-bacterial, anti-viral, anti-fungal, anti-protozoal, anti-malarial, anthelmintic, anti-diarrhoeal, analgesic, antipyretic, anti-inflammatory, anti-allergic, anti-hypertensive, cardio-protective, central nervous system depressant, memory enhancer, anti-hypercholesterolaemic, hepatoprotective, anti-diabetic, anti-asthmatic, anti-thyroidic, anti-oxidant, anti-cancer, chemopreventive, radio-protective, immunomodulatory, anti-fertility, anti-ulcer, anti-arthritic, anti-stress, anti-cataract, anti-leucodermal and anti-coagulant activities (Krishna, 2014). Tulsi has been traditionally employed in hundreds of different formulations for the treatment of a wide range of disorders, including those of the mouth, throat, lungs, heart, blood, liver, kidney, stomach, metabolic, reproductive and nervous systems. Tulsi is commonly used to treat coughs, colds, flu, head and earaches, rheumatism, arthritis, malaria, fever, allergies and various skin diseases.

Tulsi is also used to reduce the toxicity of various poisons due to insect and reptile bites to expel intestinal parasites, repel insects and purify the air. It is observed that daily consumption of its leaves and its products is considered to prevent diseases, promote health, increase the life span and reduce the physical and mental stresses of daily life. It is recommended as a treatment for various conditions which includes anxiety, fever, cough, dysentery, asthma, arthritis, eye diseases, back pain, skin diseases, gastric, vomiting, cardiac diseases, genitourinary disorder, hiccups, ringworm, insect bite, malaria, otalgia, common cold, indigestion, constipation, headache, respiratory disorder, diabetes and other abnormal health conditions (Sah *et al.*, 2018).

All parts of tulsi particularly the leaves are used in medicine. The aromatic leaves of tulsi are used in fresh and dried forms. On steam distillation, it yields a bright yellow volatile oil possessing a pleasant odor. The high economic value of tulsi oil is due to the presence of phenyl propanoids like eugenol (71 %), eugenol methyl ether (20 %), carvacrol (3 %) and a small quantity of nerol, caryophyllene, selinene, α -pinene, β -pinene, camphor, cineole and linalool, *etc.* (Smitha *et al.*, 2015). The essential oil obtained by steam distillation from shoot bio-mass has high commercial value and is used as flavoring agents in food industry, fragrance, aromatherapy, traditional rituals and medicines (Kalita and Khan, 2013).

Good agronomic practices in medicinal plants include the production of toxins and heavy metal-free raw materials. Among good agronomic practices, organic cultivation is of utmost importance. Organic agriculture has exhibited the best possible relationship between the earth and human beings. Soil organic matter content is the direct measure of soil fertility. The organic farming system emphasizes the use of organic matters for maintaining soil health, growth and multiplication of beneficial microbes by minimizing health hazards associated with food. Organic manures are very important for medicinal and aromatic plants to produce the best product in both quantity and quality which is safe for humans, animals and the environment. Organic fertilizers are obtained from animal sources such as animal manure or plant sources like green manure. Hence, organic manures can serve as an alternative to mineral fertilizers for improving soil structure (Dauda *et al.*, 2008).

Farmyard manure (FYM) refers to the decomposed mixture of dung and urine of farm animals along with litter and leftover material from roughages or fodder fed to the cattle. More than 50 per cent of the organic matter that is present in dung is in the form of complex products consists of lignin and protein which are resistant to further decomposition and therefore the nutrients present in dung are released very slowly. The nutrients from urine become readily available. On average well-decomposed farmyard manure contains 0.5 per cent N, 0.2 per cent P₂O₅ and 0.5 per cent K₂O. FYM supplies all major nutrients (N, P, K, Ca, Mg and S) necessary for plant growth as well as micronutrients (Fe, Mn, Cu and Zn). Hence, it acts as a mixed fertilizer. FYM improves soil physical, chemical and biological properties. Improvement in the soil structure due to FYM application leads to a better environment for root development. FYM also improves soil water holding capacity. The quantity and quality of FYM depend upon the type (draught or mulch) and age of the animals, the way they are feed and the care taken to collect and store the material. Vegetable crops like potato, tomato, sweet potato, carrot, radish, onion, *etc.* respond well to the farmyard manure. The other responsive crops are sugarcane, rice, napier grass and orchard crops like oranges, banana, mango and plantation crops like coconut.

Vermicompost is the product of the decomposition process using various species of worms, usually red wigglers, white worms and other earthworms to create a mixture of decomposing vegetable or food waste, bedding materials and vermicast. Vermicompost is

considered a rich source of macro and micro elements, vitamins, enzymes and growth-stimulating hormones which accelerate the growth of medicinal plants. It also increases the access to nitrogen and phosphorus by increasing the nitrogen fixation and dissolving phosphorus (Prabha *et al.*, 2007). Most nutrients in vermicompost are nitrates, phosphates, exchangeable calcium and soluble potassium. Vermicompost contains 1.02 per cent of total N, 0.3 per cent of P_2O_5 and 0.24 per cent of K_2O . Vermicompost has many microsites for microbial activity and strong retention of nutrients. Plant growth regulators and other materials which are affecting the growth are also available in vermicompost.

Poultry manure, sometimes called chicken manure is an excellent soil amendment that provides nutrients for growing crops and also improves soil quality when applied wisely because it has high organic matter content combined with available nutrients for plant growth. Poultry manure contains 2.2 per cent of total N, 1.8 per cent of P_2O_5 and 1.1 per cent of K_2O . The chemical composition of poultry manure varies with factors such as the source of manure, feed of the birds, age, condition of the birds, storage, handling of manure and litter used. Poultry waste consists of droppings, wasted feed, broken eggs, feathers and sometimes sawdust from the poultry floor. It also includes the dead birds and hatchery waste, all of which are high in protein and contain a substantial amount of calcium and phosphorus due to the high level of mineral supplements in their diet. Poultry manure has been reported to contain more plant nutrients than all other organic manures.

Only the organically grown produce has export demand in the pharmaceutical industry as it produces chemical-free drugs and it is also used daily in medicines to cure many ailments, hence, there is a strong need to boost the organic production of tulsi. The cultivation of tulsi on a commercial scale provides great profit as organics increase the herb yield and maintains the quality. The work done on the cultivation of tulsi using organics is scanty. Hence, the present investigation was taken up with the following objectives.

1. To investigate the influence of organic manures on growth and yield of tulsi.
2. To assess the impact of organic manures on the essential oil content of tulsi.
3. To work out the economics of organic cultivation of tulsi.

Review of Literature

II. REVIEW OF LITERATURE

Use of organic manures to meet the nutrient requirement of crops would be an inevitable practice in the years to come for sustainable agriculture. Application of organic manures not only improves the physical condition of the soil but also helps in better growth, nutrient uptake and in turn, increases the yield. The information on the use of farmyard manure, vermicompost and poultry manure in medicinal crops in general and tulsi in particular is scanty. Therefore, the literature on the use of organic manures pertaining to other related crops is reviewed. The literature collected is presented in this chapter under the following headings.

- 2.1 Concept of organic farming
- 2.2 Importance of *Ocimum* species
- 2.3 Effect of farmyard manure on growth, yield and quality of tulsi and other crops
- 2.4 Effect of vermicompost on growth, yield and quality of tulsi and other crops
- 2.5 Effect of poultry manure on growth, yield and quality of tulsi and other crops
- 2.6 Effect of organic manures on soil physical and chemical properties
- 2.7 Economics of organic cultivation of medicinal and aromatic crops

2.1 Concept of organic farming

According to Lampkin (1990), the principle elements to be considered while practicing organic farming are creating healthy soil, making nutrient and energy flows in the soil ecosystem, keeping the biological life forms in the cycle and sustainable yield.

Bhattacharya (2004) stated that organic agriculture relies on crop rotation, crop residues, animal manure, legumes, green manure, off-farming organic waste and aspects of biological pest control.

Organically grown medicinal and aromatic crop products are not only readily accepted in the global markets, but also command higher prices than those cultivated using chemical inputs. Globalization has increased the demand for Indian medicinal and

aromatic plants. India has an excellent potential to emerge as a global leader both in the medicinal and aromatic plants sector (Rao and Rajput, 2005).

Rao and Rajput (2005) have reported that organically grown medicinal and aromatic crop products are not only readily accepted in the global markets, but also command higher prices than those cultivated using chemical inputs. There is a possibility for shifting to integrated nutrient and pest management practices from the current chemical cultivation techniques and then resorting to organic farming in a phased manner.

Aishwath and Tarafdar (2008) concluded that medicinal and aromatic plants perform better with organic manures, bio-fertilizers and mycorrhizal association. Crop rotations and intercropping also add value per unit area and helps in the control of disease, pests and weeds. Organic manures and mulches not only improve the yield and control weeds but also provide the organic matter and nutrients to the soil and ultimately improve the soil health.

The management practices with organic materials influence agricultural sustainability by improving the physical, chemical and biological properties of soils and it is an effective means of improving the structure and fertility of the soil (Saha *et al.*, 2008).

Irrespective of the type of crops the concept of organic agriculture builds on the idea of the efficient use of locally available resources as well as the usage of adapted technologies (e.g. soil fertility management, closing of nutrient cycles as far as possible, control of pests and diseases through the management and natural antagonists). It is based on a system-oriented approach and can be a promising option for sustainable agricultural intensification in the tropics, as it may offer several potential benefits (Watson *et al.*, 2008).

Chandrashekar (2010) stated that agriculture can be sustainable only if it has long-term economic viability. Organic farming ensures long-term economic sustainability than modern chemical fertilizers and pesticides-based farming.

Organic farming can provide quality food without adversely affecting the soil's health and the environment. Certified organic products *i.e.* all varieties of food products including basmati rice, pulses, honey, tea, spices, coffee, oilseeds, fruits, cereals, herbal

medicines and their value-added products are produced in India. Non-edible organic products include cotton, garments, cosmetics, functional food products, body care products and similar products. (Yadav *et al.*, 2013).

Raei and Milani (2014) stated that those farmers who adopted organic management practices found a way to improve the quality of their soil or at least stemmed the deterioration. The system would become productive in long term by protecting soils, enhancing their fertility and ensuring productive capacity for future generations.

In the development and implementation of sustainable agriculture techniques, organic farming is of great importance in order to alleviate the deterioration of natural and environmental pollution. There is an increasing need for the management of the traditional processes of nutrient management to result in higher nutrient concentration in soil and also to reduce environmental pollution. Organic manure influences the plant growth by enhancing root biomass, total root surface area, higher absorption of nutrients and increase in yield by reducing consumption of natural sources of energy. Organic fertilizers have proved that their application has the potential to increase the biomass and productivity of a wide range of crops (Prasad *et al.*, 2017).

Asokan and Murugan (2018) stated that organic farming is a practice that relies more on using sustainable methods to cultivate crops and it avoids chemical inputs that do not belong to the natural ecosystem. Organic farming is one of the several approaches found to meet the objectives of sustainable agriculture. Eco-friendly organic farming practices are the answer to the problems being faced by agriculture in India today. It will also keep agriculture more sustainable. This form of agriculture conserves our soil and water resources, protects our climate, improves agro-diversity, ensures biodiversity and meets the demand for food and safeguards livelihoods.

The use of organic fertilizers and microbial symbiosis with species of medicinal and aromatic plants helps in the improvement of yield and quality. Along with improvement in the yield, organic fertilizers also controls weeds and provides organic matter and nutrients to the soil. This ultimately improves soil health. Aromatic plants perform better in terms of yield and quality under organic farming system (Badalingappanavar *et al.*, 2018).

2.2 Importance of *Ocimum* species

Ayurvedic preparation containing *Ocimum sanctum*, *Allium sativum*, *Piper nigrum* and *Curcuma longa* has been shown to possess anti-malarial activity against *Plasmodium vivax* and *Plasmodium falciparum* and the preparation has been found to relieve the clinical symptoms in 52 per cent of *Plasmodium vivax* patients and 100 per cent of *Plasmodium falciparum* patients (Prakash and Gupta, 2005).

Mondal *et al.* (2009) reported that the medicinal properties of *Ocimum sanctum* are known for thousand years to various civilizations of the world. This medicinal herb is considered as a sacred plant by the Hindus in the Indian subcontinent. Scientific explorations of traditional belief of medicinal properties of tulsi have got momentum mostly after the middle of the 20th century.

Rushikesh *et al.* (2010) reported the larvicidal activity of hydro distilled oil obtained from fresh leaves of *Ocimum tenuiflorum* on *Aedes aegypti* Instar III mosquito larvae. The volatile oil showed IC₅₀ value of about 291.29 ppm. The maximum activity showed at a concentration of 500 µg per ml was about 64 per cent. Thus, the essential oil was very useful in preventing mosquito-borne diseases such as malaria, dengue, *etc.*

Kumar *et al.* (2010) stated that *Ocimum sanctum* is useful in the treatment of respiratory disorder. A decoction of the leaves, with honey and ginger, is an effective remedy for bronchitis, asthma, influenza, cough and cold. A decoction of the leaves, cloves and common salt also gives immediate relief in case of influenza.

Ocimum basilicum acts as a strong anti-viral agent against DNA viruses like Herpes virus (HSV), Adenoviruses (ADV), Hepatitis B virus and RNA viruses (Bora *et al.*, 2011).

Sharma *et al.* (2011) reported the biochemical estimation of primary metabolites in *in vivo* plant parts (leaves, stem and root) and *in vitro* (callus) of *Ocimum tenuiflorum* like total soluble sugar, starch, lipid, protein and phenol. The plant parts varied in the composition of their primary metabolites. The results showed the maximum content of total soluble sugar (3.5 ± 0.08 mg/g fw), lipid (2.6 ± 0.11 mg/g fw), protein (3.6 ± 0.65 mg/g fw) and phenol (1.8 ± 0.456 mg/g fw). Maximum starch was found in roots (2.1 ± 0.14 mg/g fw).

Verma *et al.* (2011) studied the potential of *Ocimum gratissimum* and *Ocimum kilimandscharicum* essential oils produced during the spring-summer cropping season in the subtropical region of India. The major components of the *Ocimum gratissimum* essential oil were eugenol (63.7 %), (Z)- β -ocimene (19.6 %) and germacrene D (7.3 %), while the principal components identified in the *Ocimum kilimandscharicum* essential oil were camphor (63.4 %), limonene (7.9 %), camphene (5.8 %) and γ -terpinene (4.7 %). Anti-microbial activity of these two essential oils is mainly due to the presence of eugenol and camphor which were noticed in significant amount in the spring-summer season.

Ocimum sanctum owes a stronger, somewhat pungent taste than other basil due to beta-caryophyllene, a sesquiterpenoid and eugenol which is a phenylpropanoid which is present in the leaf essential oil obtained after hydro distillation. The oil is applied to reduce joint pains, inflammation and body rashes (Bhasin, 2012).

Ocimum tenuifolium is an important medicinal plant with a diverse pharmacological spectrum. The plant shows the presence of many chemical constituents which are responsible for varied pharmacological and medicinal properties. *Ocimum tenuifolium* was reported to have anti-cancer, anti-microbial, antiseptic, anti-fungal and anti-viral properties (Palla *et al.*, 2012)

The chemopreventive and radiopreventive property of *Ocimum sanctum* along with its anti-oxidant, anti-inflammatory, anti-stress and anti-cancerous property was documented. It is demonstrated that various phytochemical constituents such as eugenol, orientin, vicenin-2, linolenic acid and ursolic acid are behind this effect. *Ocimum sanctum* could be effective in treating cancer such as skin, lung, breast, prostate, cervical, oral and gastric carcinoma (Joseph and Nair, 2013).

Ocimum sanctum can help to prevent the decrease in severity and duration of the swine flu by improving the body's overall defense mechanism including its ability to fight viral diseases. It can help in speeding up the recovery process and also help in strengthening the immune system of the body (Krishna, 2014).

Ansari (2015) reported that the *Ocimum sanctum* is beneficial in treating teeth disorders. Its leaves dried under the sun and powdered are used for brushing teeth. It may be mixed with mustered oil to form a paste and used as a dentifrice.

Methanolic fraction and aqueous fraction of *Ocimum sanctum* showed anti-fungal activity against dermatophytic fungus such as *Trichophyton mantagrophytes*, *Trichophyton rubrum*, etc. Aqueous fraction showed better anti-dermatophytic activity as compared to methanolic fraction (Summy and Patyal, 2016).

Verma (2016) reported that the leaf juice of *Ocimum sanctum* along with Triphala is used in ayurvedic eye drop preparations recommended for glaucoma, chronic conjunctivitis and other painful eye diseases. In a daily routine, one may use about three drops of tulsi oil along with honey and it is supposed to improve eyesight.

Sah *et al.* (2018) reported that *Ocimum sanctum* had strong anti-carcinogenic effects due to the presence of eugenol, ursolic acid, oleanolic acid and ethanolic extract. The effects against carcinogenic genes, modulation of carcinogen and inactivation of enzymes such as cytochrome P-450, cytochrome b5 and hydrocarbon hydroxylase are responsible for the anti-carcinogenic effect. It also prevents the activity of cancer-causing compounds that induce apoptosis and damage of genetic materials.

2.3 Effect of farmyard manure on growth, yield and quality of tulsi and other crops

In *Zingiber officinale*, Khandkar and Nigam (1996) observed the highest plant height (39.3 cm), number of leaves (20.30), tillers per plant (3.7) and yield (3300 kg ha⁻¹) due to the application of FYM (6 t ha⁻¹) compared to control.

In *Maranta arundinaceae*, Maheshwarappa *et al.* (1998) noticed that combined application of FYM (20 t ha⁻¹) and NPK (75:50:50 kg ha⁻¹) resulted in the highest plant height (116.8 cm), number of tillers (6.60), number of leaves (40.2) and leaf area (4211.5 cm²) per plant.

In a study on *Withania somnifera*, variety JA-20, the highest dry root yield (881 kg ha⁻¹) and maximum net returns (Rs. 29,390 ha⁻¹) were recorded by the application of 2.5 tons of FYM per hectare along with 12.5 kg nitrogen per hectare and 25 kg phosphorus per hectare under rainfed conditions on shallow black soils. In the same study, JA-20 and JA-134 recorded higher root yield (862 and 425 kg ha⁻¹, respectively) and total alkaloid content (0.139 and 0.140 %, respectively) in roots by the application of FYM at 5 tons per hectare compared to inorganic fertilizers (Maheshwari *et al.*, 2000).

A fertilizer dose of 60:20:40 kg of NPK per hectare with 10 tons of FYM produced the highest plant height (103.78 cm), primary branches (3.96), secondary branches (31.42) per plant and fruit yield (5.87 t ha⁻¹) in *Solanum khasianum* (Sundharaiya *et al.*, 2000).

Bhaskar *et al.* (2001) reported a significant increase in total herbage yield (99.5 t ha⁻¹) and oil yield (224.3 kg ha⁻¹) from four harvests in *Pelargonium graveolens* due to the application of 30 tons of FYM per hectare.

Chand *et al.* (2001) recorded the highest herb yield (28.81 t ha⁻¹ and 24.71 t ha⁻¹) and oil yield (216.0 t ha⁻¹ and 222.4 t ha⁻¹) in *Mentha arvensis* with combined application of FYM (6.7 t ha⁻¹) and NPK (133:40:40 kg ha⁻¹) during the first and second years, respectively.

Khiriya *et al.* (2001) studied the effect of different levels of farmyard manure and phosphorus on growth of two *Trigonella foenum-graecum* genotypes in sandy loam soils. The results indicated that plant height, leaf area index, crop growth rate, dry matter accumulation and seed yield were significantly higher with the increase of FYM upto 15 tons per hectare at all stages of crop growth.

In *Kaempferia galanga*, application of FYM at 20 tons per hectare with NPK (50:50:50 kg ha⁻¹) resulted in more number of rhizomes per plant (9.1), fresh rhizome yield (6.2 t ha⁻¹) and harvest index (0.629) which were significantly higher when compared to FYM, vermicompost, composted coir pith or major nutrients applied alone (Maheshwarappa *et al.*, 2001).

A field experiment was conducted by Chouhan and Joshi (2002) on *Chlorophytum borivilianum* with four levels of FYM (0, 15, 30 and 45 t ha⁻¹) revealed that application of FYM at 30 tons per hectare recorded significantly higher tuber yield.

Joy *et al.* (2002) obtained the highest plant height (90.18 cm), number of leaves per sucker (10.23) and fresh rhizome yield (45.14 t ha⁻¹) in *Alpinia galangal* with the application of FYM at 20 tons per hectare per year.

Kothari and Singh (2003) documented that application of FYM at 24 tons per hectare produced maximum plant height (23.8 cm), plant spread (32.7 cm) and number of leaves per plant (24.2) in *Chlorophytum borivilianum* under arid tropics of Hyderabad.

In *Artemisia annua* the application of FYM (15 t ha⁻¹) with microbial inoculum resulted in higher fresh herbage yield (18.38 and 9.57 t ha⁻¹), dry herbage yield (10.39 and 5.37 t ha⁻¹) and oil yield (121.29 and 55.50 l ha⁻¹) in main and ratoon crops, respectively (Kumaravel, 2003).

Subramanian *et al.* (2003) obtained higher yield in *Curcuma longa* with the application of FYM (5 t ha⁻¹) + inorganic N (75 % + *Azospirillum* (5 kg ha⁻¹) and the cost-benefit ratio was the highest (1:2.28) in the same treatment.

Significant increase in the number of tillers per plant (6.84), number of spikes per plant (40.74), grains per spike (667.16), grain and straw yield (16.59 and 35.93 q ha⁻¹, respectively) was recorded in *Plantago ovata* due to the application of nitrogen through urea (25 %) and FYM (75 %) (Yadav *et al.*, 2003).

Application of FYM at 15 tons per hectare in *Phyllanthus amarus* resulted in maximum shoot and root length. Also, the compound leaves per plant, number of fruits and seeds per plant were found to be maximum (Annamalai *et al.*, 2004).

Chalapathi *et al.* (2004) stated that application of FYM (10 t ha⁻¹) produced higher herbage yield (16.5 t ha⁻¹), essential oil content (0.63 %) and essential oil yield (26 kg ha⁻¹) in *Artemisia pallens*.

Application of FYM (25 t ha⁻¹) along with a recommended dose of fertilizers resulted in the highest plant height, number of tillers and higher yield in *Curcuma longa* (Vishwanath *et al.*, 2004).

Joy *et al.* (2005) revealed in *Curculigo orchioides* that 30 tons of FYM was optimum and substitution of FYM to the tune of 25 per cent with inorganic fertilizers was ideal for realizing the highest rhizome yield of good quality. Application of 22.5 tons of FYM and 10:8:5 kg of N, P₂O₅ and K₂O per hectare is ideal for realizing the highest yield of quality rhizome.

Sushma and Pawan (2006) inferred that in *Phyllanthus fraternus*, maximum plant height and collar diameter were obtained due to the application of FYM and compost treated plants, respectively. Aerial and underground biomass increased significantly with FYM application when compared to other treatments.

Badawy *et al.* (2009) conducted two field experiments during two successive seasons to study the response of *Dracocephalum moldavica* to different levels of two organic fertilizers (Compost and FYM) at 240, 480 and 720 kg nitrogen per hectare. The highest values of essential oil (%) were recorded in treatment consisting of application of 240 kg nitrogen through FYM per hectare in the first season.

Datta *et al.* (2009) conducted a field experiment during 2003-04 and 2004-05 to study the effect of different levels of farmyard manure (0, 12.5, 25, 37.5 and 50 t ha⁻¹) and GA₃ (0 and 100 ppm) on production of *Acorus calamus*. Plant height, number of leaves, rhizome length, rhizome diameter and yield increased with increase in the dose of FYM from 0 to 50 tons per hectare. Maximum fresh and dry rhizome yield (3013.23 and 1389.15 kg ha⁻¹, respectively) was recorded in 50 tons per hectare of FYM.

Jayasri and Anuja (2010) observed that application of FYM at 25 tons per hectare + *Azospirillum* + phosphobacteria + panchagavya (3 %) as foliar spray recorded the highest plant height (64.11 cm) and number of branches per plant (35.86) in *Ocimum basilicum*.

Rashid *et al.* (2013) experimented to study the effect of different levels of farmyard manure and nitrogen on yield and nitrogen uptake by *Stevia rebaudiana*. The results revealed that biomass yield (kg leaves ha⁻¹), dry leaf yield, number of leaves per plant, leaf area index and dry matter accumulation per plant were highest in plants grown at the highest level of FYM (45 t ha⁻¹). Maximum nitrogen uptake was also recorded under the same treatment.

A field experiment was conducted by Choudhary *et al.* (2014) to assess the effect of inorganic fertilizers and organic manure on plant growth and seed quality of *Plantago ovata* and the results showed those plant growth parameters *viz.*, plant height, number of tillers per plant, dry matter accumulation and yield attributes such as spike length, number of spikes per plant and number of grains per spike were significantly higher with NPK + FYM application.

Goel and Duhan (2014) reported that FYM at the rate of 12.5 tons per hectare in combination with 12.5 mg P₂O₅ per kg soil significantly improved all the vegetative parameters in *Withania somnifera*, whereas, FYM at the rate of 12.5 tons per hectare in combination with 25 mg P₂O₅ per kg soil significantly enhanced the dry weight of the roots.

Rahman *et al.* (2014) recorded the highest plant height (71 cm), number of branches per plant (17), number of leaves per plant (163), leaf length (4.9 cm) and 1000 fresh leaf weight (91 g) were obtained with the application of cow dung (5 t ha⁻¹) in *Ocimum sanctum*.

Plants provided with FYM equivalent to 100 per cent recommended dose of nitrogen gave 1.28 tons per hectare of dry tuberous root yield. Higher forskolin content (1.037 %) was recorded in press mud equivalent to 100 per cent RDN treatment. As far as fresh and dry tuberous root yield was concerned, significantly higher fresh (26.59 %) and dry tuberous root (15.65 %) yield were obtained with the application of FYM equivalent to 100 per cent RDN in *Plectranthus forskohlii* (Saraswati *et al.*, 2015).

Al-Mansour *et al.* (2017) deduced that, application of recommended FYM (10 t ha⁻¹) along with recommended NPK (160:80:80 kg ha⁻¹) registered the highest plant height (81.22 and 60.20 cm), number of branches (30.25 and 24.10), leaf area (16.35 and 9.80 cm²), fresh herbage yield (39.95 and 19.37 t ha⁻¹), dry herbage yield (8.43 and 3.76 t ha⁻¹) and oil yield (199.7 and 107.58 L ha⁻¹) of *Ocimum basilicum* main crop and ratoon crops, respectively.

Application of FYM at the rate of 10 tons per hectare recorded the highest number of leaves (86.88), leaf length (44.08 cm) and difference in leaf emergence (2.32) in *Acorus calamus*, while highest plant height (54.88 cm) and leaf width (4.58 cm) were recorded with the application of FYM at 15 tons per hectare (Priya *et al.*, 2018).

2.4 Effect of vermicompost on growth, yield and quality of tulsi and other crops

Vadiraj *et al.* (1998) observed a significant difference in plant height and leaf area between treated (vermicompost applied) and control. They further reported that vermicompost produced a significantly higher yield when compared to control plots in all the *Coriandrum sativum* varieties.

Maheshwarappa *et al.* (2001) concluded that the use of vermicompost (2.4 t ha⁻¹) produced more leaves (11.7) and leaf area (303.4 cm²) in *Kaempferia galanga*.

Application of vermicompost at 2.5 tons per hectare along with inorganic fertilizers resulted in higher plant height, herbage and oil yield (70.2 cm, 11.98 t ha⁻¹ and 31.61 kg ha⁻¹, respectively) in *Ocimum basilicum* (Singh and Ramesh, 2002).

Application of vermicompost at 2.5 tons per hectare along with inorganic fertilizers resulted in higher oil yield (57.88 kg ha⁻¹) in *Ocimum sanctum* (Singh and Ramesh, 2002).

Chand *et al.* (2011) concluded that the application of vermicompost and inorganic fertilizers produced higher herbage and oil yield of *Pelargonium hortorum* when compared to control. Maximum nitrogen and phosphorus uptake were recorded under combined application of 50 per cent NPK + vermicompost at 5 tons per hectare.

Application of vermicompost at 2 tons per hectare along with *Azotobacter* gave significantly higher fasciculated root yield (4444 kg ha⁻¹) and it showed significantly the highest saponin content (1.494 %) in *Chlorophytum borivillianum* (Gaikwad *et al.*, 2011).

Hadi *et al.* (2011) reported the highest fresh flower yield (7539.45 kg ha⁻¹), dry flower yield (1715.93 kg ha⁻¹) and essential oil yield (6.95 kg ha⁻¹) in plots, which received 135 kg ha⁻¹ ammonium nitrate + 3 ton vermicompost ha⁻¹ *Matricaria chamomilla*.

Singh (2011) found that application of vermicompost (7.5 t ha⁻¹) + 25 per cent recommended NPK (25:12.5:12.5 kg ha⁻¹) produced maximum biomass (28.2 q ha⁻¹), seed (10.82 q ha⁻¹) and oil yield (6.53 kg ha⁻¹) in *Coriandrum sativum*.

Darzi *et al.* (2012) documented the highest essential oil content in seed and carvone content in the essential oil of *Anethum graveolens*. Minimum dillapiole content in essential oil was obtained after applying vermicompost of 4 tons per hectare and the maximum essential oil yield was obtained after applying vermicompost of 8 tons per hectare to the crop.

The highest shoot dry weight (28.28 %), shoot wet weight (13.77 %), essence yield (24.84 %), plant height (13.2 %) and leaf area (17.17 %) with the enhanced application of vermicompost at 5 tons per hectare relative to control in *Ocimum basilicum* (Befrozfar *et al.*, 2013).

Prabu and Arumugam (2013) revealed that application of vermicompost at 2.5 t ha⁻¹ + humic acid 0.2 per cent + panchagavya 3 per cent resulted in improving the growth characters like plant height (35.22 cm), plant spread (22.49 cm), number of laterals per plant (25.67), number of leaves per plant (205.80) and leaf area (16.40 cm²) in *Mentha arvensis*.

Raja and Veerakumari (2013) stated that substitution of vermicompost with chemical fertilizers is quite useful in *Withania somnifera* for higher growth, yield, alkaloid compound and it helps in getting higher marketable alkaloid compound such as withaferin A and withanolide D.

Yadav *et al.* (2013) inferred that *Ocimum basilicum* plants treated with vermicompost of 3 tons per hectare showed higher plant height, crop dry matter, primary and secondary branches per plant, number of siliqua per plant, seeds per siliqua and test weight to the extent of 15, 16.3, 33.5, 39.2, 27, 5.2 and 11.3 per cent, respectively.

Ayyobi *et al.* (2014) observed in *Mentha piperita* plants treated with vermicompost at 7 metric tons per hectare exhibited the highest plant height (74.5 cm), number of leaves (131.07), number of nodes (11.56) and number of lateral branches (20.91).

Dushyant *et al.* (2014) revealed that combined application of vermicompost and bone meal at 75:25 ratio showed the maximum height of plant (49.99 cm), highest number of suckers per plant (3.52), maximum number of leaves (89.87 plant⁻¹) as well as maximum fresh (26.55 g) and dry weight (7.52 g) in *Stevia rebaudiana*.

Shirkhodaei *et al.* (2014) conducted an experiment to determine the influence of vermicompost and bio-stimulant on the growth and biomass of *Coriandrum sativum*. Highest fresh weight per plant, dry weight per plant and biomass yield was obtained after applying 9 tons of vermicompost per hectare. The results also showed that the interaction

of vermicompost and biostimulant were significant on fresh weight and dry weight of plant.

Kumar *et al.* (2015) experimented to assess the effect of nutrient supplementation through organic sources on growth, yield and quality of *Coriandrum sativum*. The maximum plant height, number of primary and secondary branches, number of umbels per plant, number of umbellets per umbel, number of seeds per umbel, weight of 1000 seeds and seed yield (14.58 q ha⁻¹) were recorded with the application of 25 per cent FYM (5 t ha⁻¹) + 75 per cent vermicompost (3.75 t ha⁻¹).

Vermicompost and planting density treatments had a significant effect on the rate of active substances in *Aloe barbadensis*. The highest amount of aloin and aloe-emodin was measured as 1193.3 µg per gram and 536.3 µg per gram, respectively in the fertilizer treatment of 15 tons per hectare and density of 4 plants per m² (Nematian and Tomovska, 2015).

Raha (2015) studied the effect of vermicompost on the growth, yield and quality of *Chrysanthemum coronarium cv. Kasturba Gandhi*, the results showed best vegetative growth and flowering in 40 per cent vermicompost and 60 per cent basal media mixture and vermicompost had positive effects on fresh and dry weights of shoot, leaf numbers, disease resistance, times to flowering, size, weight and duration of flower of *Chrysanthemum coronarium* compared to control media.

Application of vermicompost at 10 tons per hectare exhibited maximum bush height (8.14 cm) and number of lateral branches (18.7) in *Origanum maorana* (Rahimi, 2015).

Growth and yield attributes such as plant height, number of branches, number of leaves, leaf area, fresh weight and dry weight of leaves were significantly influenced by different levels of vermicompost in *Stevia rebaudiana*. All the plant parameters increased with the advancement of growth period as well with the increased rate of vermicompost up to 7.5 tons per hectare (Zaman *et al.*, 2015).

Abaszadeh *et al.* (2016) deduced that the highest leaf yield (2206.4 kg ha⁻¹), annual stem yield (7133.2 kg ha⁻¹), annual branches yield (9933 kg ha⁻¹), total biological

yield (1333.6 kg ha⁻¹) and essential oil yield (82.67 kg ha⁻¹) were enhanced at 15 tons per hectare of vermicompost treatment in *Lavandula angustifolia*.

Kansotia *et al.* (2016) conducted a field trial to know the effect of organic sources of nitrogen on quality and yield of *Brassica nigra* under sodic water irrigation. The results revealed that the application of 50 per cent RDN through urea + 75 per cent RDN through vermicompost overcomes the adverse effects of sodium-rich water on quality and yield of *Brassica nigra*.

Mohsen *et al.* (2016) observed a significant increase in plant height (36.28 and 38.74 cm) and number of branches per plant (15.64 and 17.60) with the application of vermicompost at 8 m³ per fedden in *Majorana hortensis*, during the first and second season, respectively.

Priya *et al.* (2016) recorded the maximum shoot length (8.2 cm), root length (10.0 cm), plant height (18.2 cm), leaf length (5.3 cm), leaf width (2.0 cm), leaf area (5.3 cm²), number of leaves (14), number of hairy roots (40) and shoot girth (0.4 cm) were obtained in vermicompost (3 g kg⁻¹) applied pots when compared to untreated pots in *Andrographis paniculata*.

Ravimycin (2016) observed that application of vermicompost increased all the morphological characters, pigment, protein and nutrient content of *Coriandrum sativum*. The germination percentage, root and shoot length, fresh and dry herb weight, total chlorophyll, carotenoid and protein content of *Coriandrum sativum* were increased by the application of vermicompost.

Sasikala *et al.* (2016) revealed that the application of vermicompost at 10 gram per plant influenced significantly and produced maximum height (86 cm), number of tillers (107) and herb production (317 g plant⁻¹) in *Cymbopogon citratus*.

Lokesh and Prajapati (2018) experimented to study the individual and combined effect of organic manure and chemical fertilizers on the growth and productivity of *Lepidium sativum*. The results exhibited maximum morphological characters *i.e.* plant height (49.33 cm), collar diameter (1.94 cm), number of leaves (30.33) and number of branches (14.33) in treatment consisting of 3 tons of vermicompost in combination with 18, 46 kg of nitrogen and phosphorus per hectare, respectively.

A field experiment was conducted by Suresh *et al.* (2018) to study the effect of organic manures on the growth of mint and revealed that application of vermicompost (2.5 t ha⁻¹) + humic Acid (0.3 %) significantly increased the growth and yield of *Mentha arvensis*.

Mahalakshmi *et al.* (2019) reported that the soil application of 50 per cent nitrogen as vermicompost + 25 per cent nitrogen as FYM + 25 per cent nitrogen as neem cake in *Piper betle* recorded the highest growth and yield parameters in terms of vine length, number of nodes per vine, number of laterals per vine, leaf length, breadth, leaf area, number of leaves per vine, fresh weight of 100 leaves, single leaf fresh and dry weight and leaf yield.

2.5 Effect of poultry manure on growth, yield and quality of tulsi and other crops

Application of poultry manure at 2.7 tons per hectare has produced maximum fresh and dry rhizome yield in *Curculigo orchoides* (Joy *et al.*, 2005).

The study of Sunilkumar (2005) revealed that the treatment of poultry manure + vermicompost in the ratio of 1:3.37 had the highest number of tubers (24.70), length of tubers (25.05 cm), diameter of tuber (1.85 cm), volume of tuber (242.03 g/cc), fresh weight of tubers (247.44 g plant⁻¹), dry weight of tuber (45.03 g plant⁻¹), yield of tubers (3.44 t ha⁻¹) and harvest index (33.2) in *Coleus forskohlii*.

Velmurugan and Chezhiyan (2005) reported that application of poultry manure at the rate of 0.5 kg m⁻³, *Azospirillum* and phosphobacteria each at 2 kilogram per hectare increased the plant height, alkaloid yield and dry matter production in *Curcuma longa*.

Mohanalakshmi and Vadivel (2008) documented that a combination of poultry manure at 5 tons per hectare and panchagavya (3 % spray) obtained a higher value of alkaloid content (0.31 %) in *Withania somnifera* under the agro-climatic condition of Coimbatore.

Patel *et al.* (2008) reported that application of poultry manure at 5 tons per hectare produced highest yield (6090 kg ha⁻¹) in *Chlorophytum borivilianum* and highest C: B ratio (1:3.67 and 1:4.10) was also observed in the same treatment.

Adewale *et al.* (2011) inferred that *Allium sativum* plants that received no poultry manure exhibited the lowest values for parameters while the plants that received poultry manure at 20 tons per hectare exhibited the highest values for parameters such as plant height, number of leaves, average number of cloves per bulb, bulb diameter, bulb weight and the overall yield.

Al-Fraihat *et al.* (2011) observed that the application of poultry manure as an organic fertilizer to *Origanum majorana* plants recorded the maximum values for herb fresh and dry yield, volatile oil percentage, oil yield per plant and hectare.

Islam *et al.* (2011) deduced that application of poultry manure at 2.5 tons per hectare + reduced RDF (34.9 t ha⁻¹ in 1st and 31.4 t ha⁻¹ in 2nd year experiment) produced maximum yield in *Amaranthus cruentus* and *Basella alba*.

Costa *et al.* (2013) have noticed that application of 11.8 kg per m² of poultry manure in *Mentha piperita* produced the highest yield of essential oil.

A field study was carried out by Enujeke and Egbuchua (2013) to evaluate the responses of *Gingiber officinale* to three sources of organic manures namely cow-dung manure, poultry manure and pig manure at the rate of 20 tons per hectare. Results showed that the plots treated with poultry manure produced the highest plant height of 12.67 cm, highest number of leaves of 14.87 and leaf area of 231.8 cm² compared to other treatments.

Detpiratmongkol *et al.* (2014) reported that application of chicken manure (12.5 t ha⁻¹) resulted in higher stem dry weight (10.94 g plant⁻¹), leaf dry weight (12.12 g plant⁻¹) and total dry weight yield (26.02 g plant⁻¹) than chicken manure at 2.5, 5, 7.5 tons per hectare in *Andrographis paniculata*.

El-Sayed *et al.* (2015) reported that using chicken manure at 10 m³ per feddan and humic acid at 125 ppm increased all growth parameters *viz.*, plant height (52.49 cm), number of branches (12.96), leaf area (17.53 cm²) compared to the other treatments in *Ocimum basilicum*.

Ihenacho *et al.* (2015) reported that application of poultry manure at 8 tons per hectare in *Curcuma longa* increased the rhizome yield (2185.7 kg ha⁻¹), dry matter (33.50

kg ha⁻¹), plant height, number of leaves per plant and leaf area significantly and enhanced flowering (151.50 days).

Zaman *et al.* (2015) observed that application of poultry manure at the rate of 5 tons per hectare in *Stevia rebaudiana* increased the leaf area, fresh weight and dry weight.

Aleman *et al.* (2016) stated that the yield of essential oil and flavonoid was higher at the irrigation depth of 150 per cent evapotranspiration associated with the poultry manure fertilization at the dose of 5 kg per m² in *Matricaria chamomilla*.

Baiyeri *et al.* (2016) stated that the growth and yield performance and nutritional quality of *Piper nigrum* could be manipulated positively by the application of poultry manure. Plant height, number of leaves and number of branches increased with increasing level of poultry manure which translated to the increased number of fruits and fruit weight per plant.

Janet *et al.* (2016) experimented to assess the effects of organic and inorganic fertilizers on the growth of *Solanum nigrum*. The results showed that poultry manure produced the tallest plants (29.37 cm) at six weeks after transplanting and the highest number of green leaves (76.25) at harvest.

Avci (2017) documented the highest herb yield and leaf yield in *Origanum onites* with the application of 20 tons of chicken manure per hectare.

Eman (2017) reported that plant height, number of branches, fresh and dry weights, photosynthetic pigments (chlorophyll a, b and carotenoids) were highest in combined treatment of chicken manure at 20 m³ per feddan and yeast extract 100 m/l in *Ocimum basilicum*.

Ullah *et al.* (2017) found maximum number of leaves per plant (19.5), higher plant height (26.66 cm), higher total chlorophyll content (0.0062 mg cm⁻²) and total yield (4.16 t ha⁻¹) in *Lactuca sativa* when they are treated with poultry manure at the rate of 10 tons per hectare.

The treatment combination of poultry manure 10 m³ per feddan + bio-fertilizer, followed by the cattle manure 10 m³ per feddan + bio-fertilizer increased the herb fresh

weight, herb dry weight, fresh weight of roots, dry weight of roots, as well as oil yield in herb and root of *Levisticum officinale* (Wafaa and El-Aleem, 2017).

Acharya and Kumar (2018) revealed that application of poultry manure at the rate of 20 tons per hectare had significant effects on plant growth characters in *Allium sativum* viz., plant height, number of leaves per plant, length and width of leaves. Highest yield (105.03 q ha⁻¹) was achieved with the same treatment.

Application of poultry manure at the rate of 15 tons per feddan produces the highest number of tillers per plant (49.07) and leaf area (83.99 cm²) in *Cymbopogon citratus*. The highest oil yield per feddan was recorded in the second season by the poultry manure at the rate of 10 tons per feddan (El-Sayed *et al.*, 2018).

Nanyanzi *et al.* (2018) stated that sole application of poultry manure increased the yield of *Solanum aethiopicum* compared to the control. Application of 24.19 tons per hectare of decomposed poultry manure leads to better performance and greater yields in *Solanum aethiopicum* than not using fertilizers.

In *Ocimum gratissimum* application of poultry manure at 3 to 4 tons per hectare was more beneficial than higher rates. Results showed that poultry manure significantly increased the number of leaves, branches per plant and plant height. The highest leaf index value, plant height, leaves and branches per plant were obtained at 16 weeks after planting with 6.5 tons per hectare poultry manure. While 4 tons per hectare poultry manure gave the highest growth rate, leaf fresh yield, dry matter of leaf, stem and seed yield per plant and per hectare (Agba, 2019).

Ghimire *et al.* (2019) conducted an experiment to evaluate the effect of combined application of urea and poultry manure on the yield and quality of two varieties of *Lactuca sativa*. The results revealed that the integration of 50 per cent or more poultry manure had significantly higher values in growth, yield and quality parameters while the use of 100 per cent N-urea had the lowest one.

Praveen *et al.* (2019) revealed that application of poultry manure + biofertilizers (*Azospirillum* + PSB) produced the longest roots (21.00 cm) with widest diameter (1.59 cm) in *Withania somnifera*. The same treatment *i.e.* poultry manure + biofertilizers

recorded maximum fresh root (1524 kg ha⁻¹), dry root (739 kg ha⁻¹) and seed yield (186.4 kg ha⁻¹).

In *Ocimum basilicum* highest fresh and dry weights were obtained from the plants grown with turkey and chicken manure at a rate of 10 to 12.5 tons per hectare (Yaldiz *et al.*, 2019).

Mirseyedi *et al.* (2020) revealed that the application of poultry manure at the rate of 225.4 grams per m² in *Matricaria chamomilla* resulted in the highest flower yield at the first harvest and the highest total essential oil yield was obtained in poultry manure (4.6 gm⁻²).

Sitaula *et al.* (2020) reported that *Allium sativum* plants that received 7 per cent urea and 25 per cent poultry manure produced the highest fresh bulb weight (14.32 ± 0.39 g) and highest total bulb yield (7.16 ± 0.19 t ha⁻¹). Seven per cent urea and 25 per cent poultry manure stood as the best combination of nitrogen fertilizers providing higher economic yields in *Allium sativum*.

2.6 Effect of organic manures on soil physical and chemical properties

Vermicompost at 5 tons per hectare and 100 per cent N, P and K increased the available N content and improved the soil towards neutrality in *Callistephus chinensis* (Nethra *et al.*, 1999).

Zebarth *et al.* (1999) stated that sandy, infertile soils can benefit from the addition of organic waste amendments. Annual applications of organic wastes for as long as 4 years increased soil organic matter content, decreased soil bulk density and increased soil water retention of a coarse-textured soil.

Celik *et al.* (2004) conducted an experiment to know the effects of compost, mycorrhiza, manure and fertilizer on some physical properties of chromoxerert soil. They found that soil physical properties were significantly affected by organic fertilizers. For soil depths of 0-15 and 15-30 cm, mean weight diameter was highest under the manure treatment while total porosity and saturated hydraulic conductivity were highest under the compost treatment and compost and manure treatments increased the available water content of soils by 86 per cent and 56 per cent, respectively.

Kannan *et al.* (2005) revealed that application of different organics with *Azospirillum* favorably influence the soil physical, chemical and biological environments such as bulk density, water holding capacity, organic carbon, available nitrogen and organic farming would able to sustain the soil fertility for a longer period by meeting the demands of present and future generation.

Ullah *et al.* (2008) found a decrease in soil pH with organic manure application in *Solanum melongena*. Availability of major plant nutrients like N, P, K and S were also increased by organic cultivation in brinjal.

Kamal *et al.* (2012) reported that the incorporation of organic manures to *Mangifera indica* trees showed a significant effect on the stability of macroaggregates of soil. T₅ receiving 50 kg of poultry manure with a recommended dose of chemical fertilizer of 690 grams of N, 158 grams of P and 200 grams of K per tree gave the highest per cent water-stable aggregate of 36.12 per cent and 18.6 per cent higher than the control.

Angelova *et al.* (2013) stated that application of compost and vermicompost have a significant effect on soil physical and chemical properties like electrical conductivity, pH, organic matter, macro and micronutrients content and application of the compost and vermicompost reduces the amount of aggressive fulvic acids, organic matter components that pose a potential environmental risk.

Nagar *et al.* (2016) reported that in *Cajanus cajan* combined application of FYM + phosphocompost (1.29 g/cc) reduces the bulk density of soil and the soil pH. Electrical conductivity, organic carbon, available nitrogen, phosphorus and potassium were also found significant in the same treatment.

Tripathi *et al.* (2017) conducted an experiment on the effect of organic manure on soil physicochemical properties under fruit-based agroforestry system and application of farmyard manure at the rate of 25 tons per hectare in peach increased the soil organic carbon and potassium. Application of vermicompost at the rate of 6 tons per hectare increased the electrical conductivity, nitrogen, phosphorus, sulphur and magnesium.

Udom *et al.* (2019) found that bulk density, total porosity, saturation water content and saturated hydraulic conductivity of the soil were significantly improved by the

application of poultry manure in *Zea mays* and they also stated that application of poultry manure generally improves the soil physical and chemical properties.

2.7 Economics of organic cultivation of medicinal and aromatic crops

Sudhakara (2005) reported that application of FYM at 15 tons + vermicompost 1 ton + bio-fertilizers 10 kg per hectare in *Coleus scutellarioides* recorded the highest net return and benefit-cost ratio.

Ravikumar *et al.* (2013) revealed that application of a recommended dose of NPK (40:60:50 kg ha⁻¹) + recommended dose of FYM (15 t ha⁻¹) + neem cake (1 t ha⁻¹) + *Azotobacter* + *Azospirillum* recorded significantly highest fresh (8.51 t ha⁻¹) and dry tuberous yield (1.41 t ha⁻¹), net income (Rs. 22,965 ha⁻¹) and cost-benefit ratio (1:1.48) as compared to recommended dose of FYM + recommended dose of NPK (C: B ratio of 1:1.02) in *Coleus scutellarioides*.

Godara *et al.* (2014) observed that recommended dose of nutrients (100 %) applied through fertilizers exhibited maximum yield (1,024 kg ha⁻¹), net returns (Rs. 59,556 ha⁻¹) and benefit-cost ratio (3.66), closely followed by 50 per cent RDF through fertilizers + 50 per cent RDF through vermicompost in *Coriandrum sativum*.

Thakur *et al.* (2014) observed that net monetary returns from the *Ocimum basilicum* crop treated with 100 per cent recommended dose of NPK fertilizer fetched a maximum net income of Rs. 36,160 per hectare with B: C ratio of 3.46 and these results are on par with the treatment receiving FYM (5 t ha⁻¹) + vermicompost (2.5 t ha⁻¹) + *Azotobacter* (1.5 kg ha⁻¹) with a net income of Rs. 25,220 per hectare with B: C ratio of 2.15. Whereas, the minimum net income was recorded (Rs. 7,950 ha⁻¹) in control.

Singh (2015) revealed that the treatment applied with FYM (15 t ha⁻¹) + NPK (50:40:30 kg ha⁻¹) was the best in improving the growth attributes of *Coriandrum sativum* and increased the yield 105.26 per cent over control and gave the highest net return of (Rs.68,370 ha⁻¹) with a benefit-cost ratio of 2.67.

Material and Methods

III. MATERIAL AND METHODS

The present investigation entitled “Studies on growth, yield and quality of tulsi (*Ocimum sanctum* L.) as influenced by organic manures” was carried out at the Herbal garden, Main Agricultural Research Station, University of Agricultural Sciences, Raichur, Karnataka during the year 2019-20. The details of material used and methods adopted for the investigation are outlined in this chapter.

3.1 Field location

The experimental site is located in the North-Eastern dry zone *i.e.* Zone - II of the region - I in Karnataka. The location corresponds to 16° 25' North latitude and 77° 33' East longitudes. The climate of the experimental location is semi-arid and the average annual rainfall is 722 mm. The elevation of the experimental site is 406 m above mean sea level.

3.2 Climatic conditions

The monthly mean meteorological data for the cropping period obtained from the observatory of Main Agricultural Research Station, Raichur is presented in Figure 1.

3.3 Soil characteristics

The soil of the experimental site was of red loam to clay loam. The soil samples collected at 15 to 30 centimeters depth before sowing of seeds were analyzed for various physicochemical properties and methods employed are presented in Table 1.

3.4 Experimental Details

Location	: Herbal garden, MARS, UAS Campus, Raichur
Crop	: Tulsi
Design	: Factorial RCBD
Replications	: 04
Treatments	: 10

Plot size : 4.2 m X 3.2 m
Spacing : 60 cm x 40 cm
RDF : 120:75:60 kg ha⁻¹

3.4.1 Treatment Details

The experiment comprised of ten treatment combinations involving two varieties and five different sources of nitrogen.

Factor I: Varieties

V₁ = Rama tulsi

V₂ = Krishna tulsi

Factor II: Sources of nitrogen

T₁ = Absolute control

T₂ = 100 % recommended nitrogen applied through inorganic fertilizers
(NPK-120:75:60 kg ha⁻¹)

T₃ = 100 % recommended nitrogen applied through 29.8 tons per hectare of FYM

T₄ = 100 % recommended nitrogen applied through 11.94 tons per hectare of
vermicompost

T₅ = 100 % recommended nitrogen applied through 9.18 tons per hectare of
poultry manure

3.4.2 Treatment combinations

V₁T₁: Rama tulsi with absolute control

V₁T₂: Rama tulsi with 100 % recommended nitrogen applied through inorganic
fertilizers (NPK-120:75:60 kg ha⁻¹)

V₁T₃: Rama tulsi with 100 % recommended nitrogen applied through FYM

V₁T₄: Rama tulsi with 100 % recommended nitrogen applied through
vermicompost

V₁T₅: Rama tulsi with 100 % recommended nitrogen applied through poultry manure

V₂T₁: Krishna tulsi with absolute control

V₂T₂: Krishna tulsi with 100 % recommended nitrogen applied through inorganic fertilizers (NPK-120:75:60 kg ha⁻¹)

V₂T₃: Krishna tulsi with 100 % recommended nitrogen applied through FYM

V₂T₄: Krishna tulsi with 100 % recommended nitrogen applied through vermicompost

V₂T₅: Krishna tulsi with 100 % recommended nitrogen applied through poultry manure

3.4.3 Experimental design and layout

The experiment was laid out in a factorial RCBD design with four replications and ten treatments. The layout and plan of the experiment is shown in Figure 2.

3.5 Cultural practices

3.5.1 Preparation of the experimental plot

The experimental field was ploughed using a tractor with a cultivator and brought to a fine tith by harrowing. Weeds and stubbles were removed from the experimental area. Then the experimental site was divided into small plots and leveled within the plots, each measuring 4.2 m x 3.2 m with spacing of 0.5 meter between two plots. The treatments were allotted to each individual plot at random as indicated in the plan of the layout. The replications were kept 0.5 meters apart to avoid the percolation of nutrients.

3.5.2 Application of organic manures

Recommended dosage of nitrogen (120 kg ha⁻¹) on plants was met through application of different organic manures as per their respective treatment combinations. The recommended dose of different organic manures comprising farmyard manure, vermicompost and poultry manure was applied to each of the plots as per the experimental plan at the time of plot preparation.

Prior to this the organic manures under study was sampled and subjected to nitrogen analysis and only after the analysis the quantity of organic manures to be applied

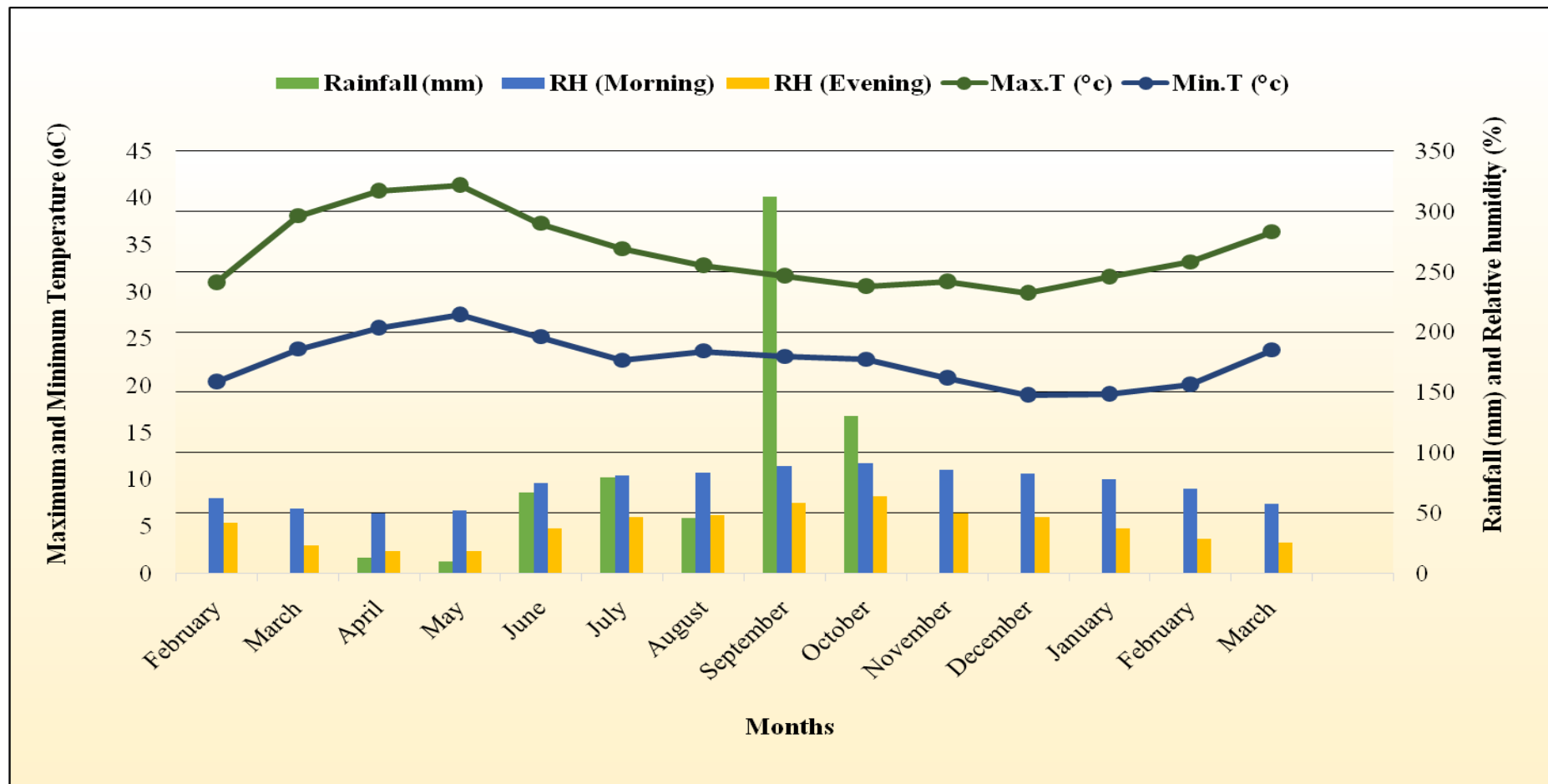


Figure 1. Mean monthly meteorological data of College of Agriculture, Raichur for the year 2019-20

in order to meet out the nitrogen demand as per the recommended dose of fertilizers was formulized. The nitrogen content of analyzed farmyard manure, vermicompost and poultry manure was 0.4, 1.0 and 1.3 per cent, respectively.

Table 1. Soil characteristics and nutrient status of the experimental plot

Soil characteristics	Particulars	Composition	Method adopted
Chemical properties	Available N (kg ha ⁻¹)	275.96	Jackson (1967)
	Available P (kg ha ⁻¹)	21.67	Jackson (1967)
	Available K (kg ha ⁻¹)	320.43	Jackson (1967)
	pH	7.73	Jackson (1967)
	EC (dS m ⁻¹)	0.28	Jackson (1967)
Physical characters	Bulk density (g cc ⁻¹)	1.68	Richards (1954)
	Field capacity (%)	21.03	Piper (1996)
	Infiltration rate (cm hr ⁻¹)	1.67	Richards (1954)
Textural composition	Sand (%)	44.25	Piper (1996)
	Silt (%)	14.50	
	Clay (%)	41.25	

3.5.3 Raising of seedlings

The seedlings were raised in protrays. The propagating mixture was cocopeat. The seeds were sown in protrays and covered with a thin layer of cocopeat mixture and then watered immediately with the help of rose headed can. The protrays were covered with a plastic bag to create humid condition and to hasten the germination. The protrays were

watered once in two days until the seeds germinated. Later the portrays were watered twice a week till the seedlings were transplanted to the main field.

3.5.4 Transplanting

Thirty days old healthy, uniform-sized seedlings were selected and transplanted in the experimental plots at a spacing of 60 cm between the rows and 40 cm between the plants as per the treatment plan. Light irrigation was facilitated to the plots before and immediately after transplanting and the required plant population was maintained by gap filling with healthy seedlings of the same age.

3.5.5 Application of fertilizers

The recommended dose of fertilizer (120:75:60 kg ha⁻¹) was applied to the respective plot as per the experimental plan by applying the same uniformly in rows and mixing it thoroughly in the soil. The nutrients NPK were applied in the form of urea, single super phosphate and muriate of potash fertilizers.

3.6 Aftercare

3.6.1 Weeding

A total of three hand weedings and couple of cycle weedings were done during the experimentation period to keep the field weed-free. In the initial stages of crop growth weeding was done by using cycle weeder to remove the weeds. First hand weeding was carried out after 30 days of transplanting. Later on weeding was done at 15 days intervals by using cycle weeder. Second hand weeding was done before the first harvest and third hand weeding was done before the final harvest.

3.6.2 Irrigation

Total seven to eight irrigations were given to crop during the growth period. The first irrigation was given immediately after transplanting. After that irrigation was given at 10 to 12 days intervals depending on the weather conditions. The crop was irrigated once a week during the dry spell.

3.6.3 Plant protection

Pests like leaf roller and leaf-eating caterpillars were noticed during the crop growth period sporadically. They were controlled by spraying neem seed kernel extract at a rate of 5 grams per liter of water.

3.6.4 Harvesting

The crop was harvested 90 days after transplanting at full bloom stage, when the lower leaves started to turn yellow, the whole plants were cut at 15 centimeters above the ground level. The harvested produce was allowed to wilt in the field for 4 to 5 hours to reduce the moisture and also the bulkiness. Then the leaves and inflorescence were separated and subjected to drying in a hot air oven until they attained constant weight. The freshly harvested inflorescence and herbage were used for the extraction of essential oil.

After the first harvest, new sprouts were encouraged from the 15 centimeters stubbles, by providing luxuriant irrigation. The biometric observations were taken as per the experimental plan and after sixty days from the first harvest, the second harvest was done by uprooting the plants along with the roots. Then the plants were dried in a hot air oven until they attained constant weight. The freshly harvested inflorescence and herbage were used for the extraction of essential oil.

3.7 Observations recorded

Observations on growth and yield parameters were recorded from five labeled plants at first (90 DAT) and second harvest (150 DAT).

3.7.1 Growth parameters

3.7.1.1 Plant height

The height of five labeled plants was measured from ground level to the growing tip with the help of a meter scale and the average was taken. The observation was recorded at 90 and 150 days after transplanting and expressed in centimeters.



R₁	V₂T₅		V₁T₄		V₂T₃		V₁T₂		V₂T₁		V₁T₅		V₂T₄		V₁T₃		V₂T₂		V₁T₁
R₂	V₁T₁		V₂T₂		V₁T₅		V₂T₃		V₁T₄		V₂T₁		V₁T₂		V₂T₅		V₁T₃		V₂T₄
R₃	V₂T₃		V₁T₅		V₂T₄		V₁T₁		V₂T₂		V₁T₄		V₂T₁		V₁T₂		V₂T₅		V₁T₃
R₄	V₁T₂		V₂T₃		V₁T₁		V₂T₄		V₁T₅		V₂T₂		V₁T₃		V₂T₁		V₁T₄		V₂T₅

Figure 2. Layout of the experimental field



Plate 1. General view of experimental plot at 90 DAT



Plate 2. General view of experimental plot at 150 DAT

3.7.1.2 Number of branches per plant

The number of branches in five tagged plants of each experimental plot was counted, averaged and recorded at 90 and 150 days after transplanting.

3.7.1.3 Leaf area

The leaf area of five tagged plants was calculated by using the Biovis instrument. The average was expressed in centimeters square per plant.

3.7.1.4 Leaf area index

Leaf area index (LAI) is defined as the leaf area per unit area. It was worked out by dividing the leaf area per plant by the land area occupied by a single plant (Sestak *et al.*, 1971).

$$\text{Leaf area index} = \frac{\text{Leaf area per plant}}{\text{Land area occupied by that plant}}$$

3.7.1.5 Plant spread

The plant spread was measured in East-West and North-South direction and recorded at 90 and 150 days after transplanting and the average was worked out and expressed in centimeters.

3.7.1.6 Chlorophyll content (SPAD meter readings)

The chlorophyll content of leaves was determined by using SPAD meter (SPAD plus 502) at 90 and 150 days after transplanting. The measurement was taken from five random leaves in each tagged plant. Several measurements were taken on each leaf and the average was worked out and expressed as SPAD readings.

3.7.2 Yield parameters

3.7.2.1 Fresh weight of flower head per plant

The flower heads of five tagged plants were harvested by secateur and weighed by using the electronic balance and the mean was worked out and expressed in grams per plant.

3.7.2.2 Dry weight of flower head per plant

Freshly harvested flower heads were kept in a hot air oven for drying at a temperature of 65 °C till a constant weight was reached. The dried flower heads were weighed on an electronic balance and the mean was recorded and expressed in grams.

3.7.2.3 Fresh weight of 1000 leaves

1000 fresh leaves from each experimental plot were hand-plucked and weighed by using the electronic balance at 90 and 150 days after transplanting and expressed in grams.

3.7.2.4 Fresh weight of shoot per plant

The fresh leaves, stems and tender parts of five labeled plants were harvested leaving five to six buds for the next harvest and weighed by using the electronic balance. The mean was worked out and expressed in grams per plant.

3.7.2.5 Dry weight of shoot per plant

Freshly harvested leaves, stem and tender parts of five tagged plants were kept in a hot air oven for drying at a temperature of 65 °C till a constant weight was reached. The leaves and stems were weighed on an electronic balance, mean was recorded and expressed in grams.

3.7.2.6 Fresh weight of herb per plant

The complete herb including fresh leaves, stems, and tender parts of five labeled plants was weighed by using the electronic balance and the mean was worked out and expressed in grams per plant.

3.7.2.7 Dry weight of herb per plant

The complete herb including fresh leaves, stems, and tender parts of five labeled plants was kept in a hot air oven for drying at a temperature of 65 °C till a constant weight was reached. The leaves, stems and roots were weighed on an electronic balance and the mean was recorded and expressed in grams.

3.7.2.8 Fresh herb yield per plot

The leaves, flowers, stem and tender shoots from the plot were harvested and weighed by using the electronic balance and this was expressed in kilograms.

3.7.2.9 Dry herb yield per plot

The freshly harvested plants were cleaned and allowed for drying at room temperature till a constant weight was obtained and was expressed in kilograms.

3.7.2.10 Fresh herb yield

The fresh herb yield was recorded at the time of harvest. The fresh herb yield was calculated based on fresh yield per plot. The fresh herb yield was expressed in terms of tons per hectare.

3.7.2.11 Dry herb yield (t ha⁻¹)

Dry herb yield was calculated based on dry herb yield per plot and expressed in tons per hectare.

3.7.2.12 Oil recovery

Tulsi essential oil estimation was done using Soxhlet extractor as per AOAC (1980). Two grams of powdered sample was refluxed with 120 ml of petroleum ether. Extraction was continued till the solvent was completely evaporated. The extract was collected in a beaker and the weight of the beaker was recorded.

$$\% \text{ Oil} = \frac{(F - T) \times 100}{S}$$

Where,

F = Weight of the beaker + oil

T = Empty weight of the beaker

S = Weight of the sample

The per cent recovery of oil was later computed and converted into grams per 100 gram.

3.7.2.13 Oil yield

Oil yield was calculated based on dry herb yield and expressed in kg per hectare.

3.7.3 Soil and plant analysis

3.7.3.1 Collection of soil samples

During the field experiment, a composite soil sample was collected from the experimental plot before sowing and after the final harvest of the crop, soil sample was collected from each plot. The collected soil samples were dried under shade, powdered using pestle and mortar and passed through a 2 mm sieve and preserved for analysis.

3.7.3.2 Available nitrogen

The available nitrogen in the soil was determined by the alkaline potassium permanganate method as suggested by Subbaiah and Asija (1956). 100 ml of 0.32 per cent KMnO_4 solution was added to 20 grams of the soil sample in an 800 ml Kjeldahl flask and then 100 ml of 2.5 per cent NaOH solution was added with distilled water. Few glass beads were added to prevent bumping. Distillation was continued and the distillate was collected at the receiver tube in the 250 ml conical flask containing 20 ml boric acid (2 %) with mixed indicator. The distillate was titrated against 0.02 N H_2SO_4 taken in burette till the pink color endpoint was observed. From the amount of H_2SO_4 consumed the amount of available nitrogen was calculated and expressed in kilogram per hectare.

3.7.3.3 Available phosphorus

Available phosphorus in the soil samples was determined by Bray's No-1 method. Two grams of soil was extracted with 40 ml of Bray's-1 solution (0.03 NH_4F and 0.025 N

HCL) and was shaken for 5 minutes by mechanical stirrer and filtered through Whatman no.1 filter paper. 5 ml aliquot was transferred into a 25 ml volumetric flask. Then 5 ml ammonium molybdate solution was added and 1 ml of diluted SnCl_2 (0.5 ml diluted to 66 ml) was added. The volume was made up to the mark. P concentration was analyzed with the help of a spectrophotometer (Model; Svstronics 106) at 660 nm. P concentration was calculated from the standard graph prepared by taking known different P concentrations and expressed in kilogram per hectare.

3.7.3.4 Available potassium

Available potassium was determined by taking 5 grams of the soil sample in a 100 ml conical flask and 25 ml of 1 N NH_4OAc solution was added to it. Then it was shaken with the help of a mechanical stirrer for five minutes and the K concentration in the filtrate was analyzed by using a flame photometer.

3.7.4 Nutrient uptake

3.7.4.1 Collection of plant sample

The collected plant samples at the time of harvest by uprooting were dried at 60°C in a hot air oven, powdered using a grinder fitted with stainless steel blades and preserved in polythene covers for further analysis and expressed in kilogram per hectare.

3.7.4.2 Estimation of nitrogen

Nitrogen in tulsi leaves was estimated by micro-Kjeldahl method (Jackson, 1973) 0.5 gram of dried sample was digested in a Kjeldahl flask with a salt mixture (1:10) of K_2SO_4 : $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ metallic selenium) and 10 ml of concentrated sulphuric acid. The digested sample was transferred to micro-Kjeldahl distillation apparatus and 4 ml of 40 per cent NaOH solution was added to it and it was distilled into 4 per cent boric acid containing mixed indicator. The distilled ammonia absorbed in boric acid was titrated with standard (0.1 N) H_2SO_4 and per cent N was calculated and expressed in kilogram per hectare.

3.7.4.3 Estimation of phosphorous

The samples were digested following the method of Piper (1965) using diacid ($\text{HNO}_3: \text{HClO}_4=3:2$) and diluted to suitable volume after filtration. P was analyzed by Vanado-Molybdo phosphoric acid yellow color method as described by Jackson (1973) at 442 nm with the help of Systronics made spectrophotometer (Model 106) and expressed in kilogram per hectare.

3.7.4.4 Estimation of potassium

The total potassium content of the di-acid digested plant samples was estimated by atomizing the digested and diluted sample to a calibrated flame photometer under suitable measuring conditions as described by Jackson (1973).

3.7.4.5 Nutrient uptake

The uptake of nutrients by different parts of tulsi plants was worked out by multiplying the nutrient content and biomass yield of the plant using the following formulae;

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{N/P/K nutrient concentration} \times \text{biomass yield}}{100}$$

3.8 Economics of organic cultivation

3.8.1 Cost of cultivation

The prices of all the inputs that were prevailing at the time of their use and the labor cost were taken into consideration while working out the cost of cultivation and the same was expressed as rupees per hectare.

3.8.2 Gross returns

The gross returns were obtained by multiplying the dry herb yield with the market price of the product and the same was expressed in rupees per hectare.

3.8.3 Net returns

Net income per hectare was obtained by subtracting the gross income by the cost of cultivation per hectare and it was expressed in rupees per hectare.

3.8.4 Benefit-cost ratio

The benefit-cost ratio in the experiment was calculated by dividing the gross return by the corresponding cost of cultivation per hectare. Benefit-cost ratio was worked out by using the following formula.

$$\text{B:C ratio} = \frac{\text{Gross returns}}{\text{Cost of cultivation}}$$

3.9 Statistical analysis

The data collected from field observations and the laboratory were subjected to statistical analysis by standard analysis of variance technique as described in "Statistical Procedure for Agricultural Research" by Gomez and Gomez (1984). For significant treatment effects, standard error of means (S.Em.±) and critical differences were calculated at a 5 per cent level of significance.

Data pertaining to different characters were tabulated and subjected to statistical analysis as per the Factorial RCBD statistical design. The analysis was done with Operational Statistics (OPISTAT) software. Comparison of treatments was also performed statistically.

Results and Discussion

IV. RESULTS AND DISCUSSION

The field experiment was conducted to assess the “Influence of organic manures on growth, yield and quality of tulsi” at the Department of Horticulture, College of Agriculture, Raichur during the year 2019-20. The results of the experiment along with statistical inferences are presented and discussed in this chapter.

4.1 Influence of organic manures on growth parameters

4.1.1 Plant height (cm)

The data on plant height of tulsi at 90 and 150 days after transplanting as influenced by different organic manures and their interactions are presented in Table 1.

4.1.1.1 At 90 days after transplanting

Significantly, higher plant height (82.99 cm) was recorded in variety Rama tulsi (V_1) as compared to variety Krishna tulsi (V_2) (80.53 cm).

The plant height of tulsi crop was significantly influenced by different organic manures at 90 days. However, significantly higher plant height (85.95 cm) was obtained with the application of 100 per cent recommended N through vermicompost (T_4) that was *on par* with T_5 (85.17 cm). Whereas, significantly lower plant height (73.00 cm) was recorded under absolute control (T_1).

The interaction effect between tulsi varieties and organic manures on plant height was found non significant.

4.1.1.2 At 150 days after transplanting

The same trend was observed for 150 days as well. Significantly, higher plant height (65.27 cm) was recorded in variety Rama tulsi (V_1) as compared to variety Krishna tulsi (V_2) (59.80 cm).

Application of 100 per cent recommended N through vermicompost (T_4) resulted in a significant increase in plant height (67.18 cm) which was *on par* with T_5 (67.11 cm). Whereas, the lower plant height (53.58 cm) was documented under absolute control (T_1).

Table 2. Influence of organic manures on plant height of tulsi varieties

Treatments	Plant height (cm)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	82.99	65.27
V ₂ : Krishna tulsi	80.53	59.80
Mean	81.76	62.53
S.Em. ±	0.62	0.32
C.D. at 5 %	1.81	0.93
MANURES		
T ₁ : Absolute control	73.00	53.58
T ₂ : Recommended dose of fertilizers	82.00	60.77
T ₃ : 100 % recommended N applied through FYM	82.67	64.02
T ₄ : 100 % recommended N applied through vermicompost	85.95	67.18
T ₅ : 100 % recommended N applied through poultry manure	85.17	67.11
Mean	81.75	62.53
S.Em. ±	0.98	0.50
C.D. at 5 %	2.87	1.47
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	73.70	55.27
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	84.50	64.50
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	84.60	67.05
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	86.60	70.07
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	85.55	69.45
V ₂ T ₁ : Krishna tulsi with absolute control	72.30	51.90
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	79.50	57.05
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	80.75	61.00
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	85.30	64.30
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	84.80	64.77
Mean	81.76	62.53
S.Em. ±	1.39	0.71
C.D. at 5 %	NS	NS

There was no significant influence of interaction observed between varieties and organic manures on plant height.

The plant height at 90 and 150 days of growth was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the plant height might be due to the genetic makeup of different varieties, their interaction with growing conditions and their expressions. Developmental morphology is inherent, but the expression of a given variety will vary in response to growing conditions as reported by Srivastava (2017).

The plant height was significantly influenced by different organic manures. Maximum plant height at 90 and 150 days of growth was recorded under vermicompost (T₄). The upsurge in plant height due to the application of vermicompost could be a result of presence of growth substances, nitrogen fixers, other essential nutrients and also due to higher phosphorus by a symbiotic mycorrhizal association as reported by Bano *et al.* (1987). Similar observations were reported by Dushyant *et al.* (2014) in *Stevia* and Suresh *et al.* (2018) in *Mentha arvensis* and.

4.1.2 Number of branches per plant

The data regarding the number of branches of tulsi varieties at 90 days and 150 days after transplanting as influenced by different organic manures and their interactions are presented in Table 2.

4.1.2.1 At 90 days after transplanting

The variety Rama tulsi (V₁) recorded significantly higher number of branches per plant (22.33) in comparison with Krishna tulsi (V₂) (21.00).

A significant variation was observed in the number of branches per plant among different organic manures. A large number of branches (23.80) were observed under 100 per cent recommended N applied through poultry manure (T₅) which was *on par* with T₄ (22.60). Whereas, the lowest number of branches (18.62) were found under absolute control (T₁).

The interaction effects were found to be non significant at 90 days after transplanting concerning the number of branches.

Table 3. Influence of organic manures on number of branches in tulsi varieties

Treatments	No. of branches	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	22.33	16.86
V ₂ : Krishna tulsi	21.00	16.25
Mean	21.66	16.55
S.Em. ±	0.21	0.15
C.D. at 5 %	0.64	0.46
MANURES		
T ₁ : Absolute control	18.62	12.72
T ₂ : Recommended dose of fertilizers	21.40	16.05
T ₃ : 100 % recommended N applied through FYM	21.90	17.45
T ₄ : 100 % recommended N applied through vermicompost	22.60	18.15
T ₅ : 100 % recommended N applied through poultry manure	23.80	18.41
Mean	21.66	16.55
S.Em. ±	0.34	0.25
C.D. at 5 %	1.01	0.73
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	19.40	13.10
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	21.85	16.35
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	22.55	17.70
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	23.40	18.45
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	24.45	18.70
V ₂ T ₁ : Krishna tulsi with absolute control	17.85	12.35
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	20.95	15.75
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	21.25	17.20
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	21.80	17.85
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	23.15	18.12
Mean	21.66	16.55
S.Em. ±	0.49	0.35
C.D. at 5 %	NS	NS

4.1.2.2 At 150 days after transplanting

Significantly, considerable number of branches per plant (16.86) were recorded in Rama tulsi (V_1) as compared to the variety Krishna tulsi (V_2) (16.25) at 150 days after transplanting as well.

Application of 100 per cent recommended N through poultry manure recorded significantly more number of branches per plant (18.41) that was *on par* with T_4 (18.15). The minimal number of branches per plant (12.72) were recorded under T_1 (Absolute control).

There was no significant influence of interaction between tulsi varieties and organic manures on the number of branches per plant.

The number of branches per plant at 90 and 150 days of growth was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the number of branches might be due to the genetic constitution of different genotypes and the interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The number of branches was considerably affected by different organic manures. A maximum number of branches at 90 and 150 days of growth was recorded under poultry manure. The increase in the number of branches as a result of application of poultry manure might be because, poultry manure readily supplies phosphorus to plants than other organic manure sources which improve the plant cell structure and increase the number of branches plant per plant. Similar observations were reported by Chandana *et al.* (2018) in kalmegh.

4.1.3 Leaf area ($\text{cm}^2 \text{ plant}^{-1}$)

The data relevant with leaf area of tulsi varieties at 90 days and 150 days after transplanting as influenced by different organic manures and their interactions are presented in Table 3 and Figure 3.

Table 4. Influence of organic manures on leaf area in tulsi varieties

Treatments	Leaf area (cm ² plant ⁻¹)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	6,575	2,757
V ₂ : Krishna tulsi	6,274	2,704
Mean	6425	2730
S.Em. ±	17.51	10.86
C.D. at 5 %	51.09	31.68
MANURES		
T ₁ : Absolute control	5,455	2,056
T ₂ : Recommended dose of fertilizers	6,119	2,503
T ₃ : 100 % recommended N applied through FYM	6,312	2,903
T ₄ : 100 % recommended N applied through vermicompost	7,181	3,166
T ₅ : 100 % recommended N applied through poultry manure	7,057	3,023
Mean	6425	2730
S.Em. ±	27.69	17.17
C.D. at 5 %	80.78	50.10
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	5,719	2,088
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	6,238	2,541
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	6,463	2,924
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	7,267	3,189
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	7,189	3,041
V ₂ T ₁ : Krishna tulsi with absolute control	5,191	2,024
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	6,000	2,465
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	6,160	2,882
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	7,094	3,143
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	6,925	3,004
Mean	6425	2730
S.Em. ±	39.16	24.28
C.D. at 5 %	114.25	NS

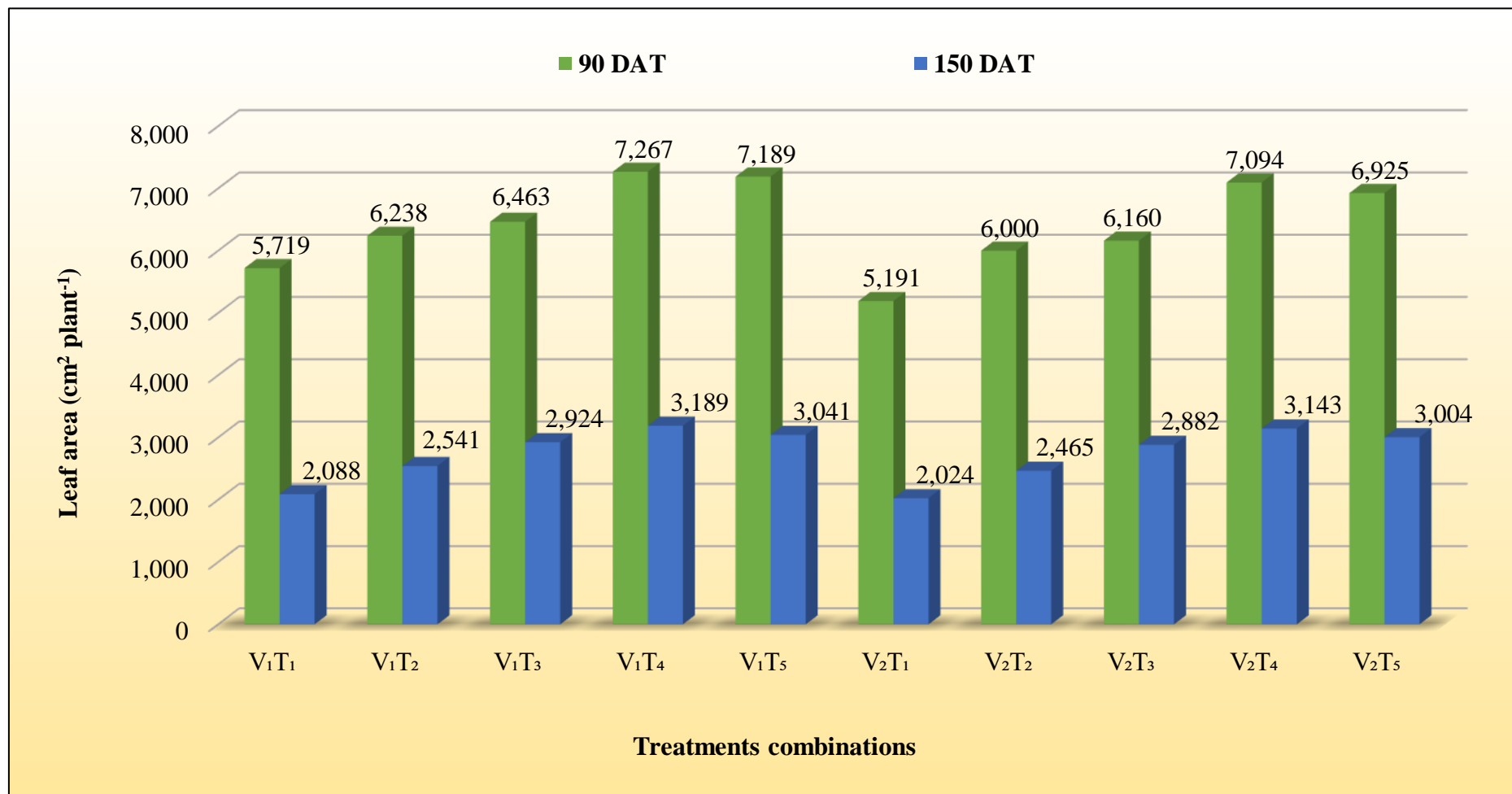


Figure 3. Influence of organic manures on leaf area of tulsi varieties



Plate 3. Plot view of Rama tulsi and Krishna tulsi

4.1.3.1 At 90 days after transplanting

The leaf area of tulsi varieties varied significantly because of applying different organic manures at 90 days after transplanting. Between the varieties, significantly higher leaf area ($6,575 \text{ cm}^2 \text{ plant}^{-1}$) was recorded in Rama tulsi (V_1) as compared to Krishna tulsi (V_2) ($6,274 \text{ cm}^2 \text{ plant}^{-1}$).

Among the different organic manures, 100 per cent recommended N applied through vermicompost (T_4) recorded substantially higher leaf area ($7,181 \text{ cm}^2 \text{ plant}^{-1}$) as compared to other organic manures. Likewise, significantly lower leaf area ($5,455 \text{ cm}^2 \text{ plant}^{-1}$) was recorded in treatment absolute control (T_1).

The interaction effect of tulsi varieties and different organic manures had a significant impact on leaf area per plant at 90 days after transplanting. Rama tulsi with 100 per cent recommended N applied through vermicompost (V_1T_4) recorded significantly higher leaf area ($7,267 \text{ cm}^2 \text{ plant}^{-1}$) that was *on par* with V_1T_5 ($7,189 \text{ cm}^2 \text{ plant}^{-1}$). Whereas, Krishna tulsi with absolute control registered significantly lower leaf area ($5,191 \text{ cm}^2 \text{ plant}^{-1}$).

4.1.3.2 At 150 days after transplanting

The variety Rama tulsi (V_1) recorded significantly higher leaf area ($2,757 \text{ cm}^2 \text{ plant}^{-1}$) as compared to variety Krishna tulsi (V_2) ($2,704 \text{ cm}^2 \text{ plant}^{-1}$).

Among different organic manures, leaf area was significantly influenced by applying different organic manures at 150 days after transplanting. Application of 100 per cent recommended N through vermicompost recorded significantly higher leaf area ($3,166 \text{ cm}^2 \text{ plant}^{-1}$) over other organic manures. Significantly, lower leaf area ($2,056 \text{ cm}^2 \text{ plant}^{-1}$) was recorded under absolute control (T_1).

The interaction effect was found to be non significant at 150 days after transplanting with respect to leaf area per plant.

The leaf area at 90 days and 150 days after transplanting was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the leaf area might be due to the genetic makeup of distinct varieties and their interaction with growing conditions. The above results were found in agreement with Mahalakshmi *et al.* (2019) in betel vine.

The leaf area was notably influenced by different organic manures. Maximum leaf area at all the stages of growth was recorded under vermicompost. The higher leaf area of tulsi under vermicompost might be because; vermicompost contains numerous humic acids that enhance the leaf area. Similar observations were reported by El-Sayed *et al.* (2018) in *Cymbopogon citratus* and Zaman *et al.* (2015) in stevia.

4.1.4 Leaf area index

The data on leaf area index of tulsi varieties at 90 days and 150 days after transplanting as influenced by different organic manures and their interactions are presented in Table 4.

4.1.4.1 At 90 days after transplanting

Leaf area index showed considerable difference within tulsi varieties. Rama tulsi (V_1) documented significantly greater leaf area index (2.42) as compared with variety Krishna tulsi (V_2) (2.32).

Application of 100 per cent recommended N through vermicompost recorded substantially higher leaf area index (2.64) as compared rest of the organic manures and considerably lower leaf area index (2.03) was recorded under absolute control (T_1).

However, the interaction effect between tulsi varieties and organic manures was non significant at 90 days after transplanting concerning leaf area index.

4.1.4.2 At 150 days after transplanting

Significantly, variety Rama tulsi (V_1) documented the higher leaf area index (1.02) as compared to variety Krishna tulsi (V_2) (0.97).

100 per cent recommended N applied through vermicompost recorded significantly higher leaf area index (1.16) over other organic manures and the lower leaf area index (0.75) was recorded under absolute control (T_1) at 150 days as well.

Table 5. Influence of organic manures on the leaf area index in tulsi varieties

Treatments	Leaf area index	
	90 DAT	150 DAT
VARIETIES		
V₁ : Rama tulsi	2.42	1.02
V₂ : Krishna tulsi	2.32	0.97
Mean	2.37	0.99
S.Em. ±	0.008	0.003
C.D. at 5 %	0.02	0.01
MANURES		
T₁ : Absolute control	2.03	0.75
T₂ : Recommended dose of fertilizers	2.26	0.91
T₃ : 100 % recommended N applied through FYM	2.33	1.03
T₄ : 100 % recommended N applied through vermicompost	2.64	1.16
T₅ : 100 % recommended N applied through poultry manure	2.59	1.11
Mean	2.37	0.99
S.Em. ±	0.01	0.006
C.D. at 5 %	0.03	0.01
INTERACTION EFFECT		
V₁T₁ : Rama tulsi with absolute control	2.11	0.77
V₁T₂ : Rama tulsi with recommended dose of fertilizers	2.29	0.94
V₁T₃ : Rama tulsi with 100 % recommended N applied through FYM	2.37	1.08
V₁T₄ : Rama tulsi with 100 % recommended N applied through vermicompost	2.68	1.18
V₁T₅ : Rama tulsi with 100 % recommended N applied through poultry manure	2.64	1.12
V₂T₁ : Krishna tulsi with absolute control	1.96	0.73
V₂T₂ : Krishna tulsi with recommended dose of fertilizers	2.23	0.89
V₂T₃ : Krishna tulsi with 100 % recommended N applied through FYM	2.28	0.97
V₂T₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	2.60	1.14
V₂T₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	2.54	1.10
Mean	2.37	0.99
S.Em. ±	0.01	0.008
C.D. at 5 %	NS	0.02

The interaction effect of tulsi varieties and different organic manures were significant impacts on leaf area index at 150 days after transplanting. Rama tulsi with 100 per cent recommended N applied through vermicompost recorded the higher leaf area index (1.18) as compared to other treatment combinations. Whereas, Krishna tulsi with absolute control recorded a significantly lower leaf area index (0.73).

The leaf area index at 90 and 150 days after transplanting was maximum in Rama tulsi and minimum in Krishna tulsi. The genetic makeup of different varieties and their interaction with growing conditions could be a reason for difference in the leaf area index.

Leaf area index was significantly influenced by different organic manures. Maximum leaf area index at 90 and 150 days after transplanting was recorded under vermicompost. The higher leaf area index of tulsi under vermicompost might be due to the increased organic carbon and nitrogen provided by vermicompost and this improvement at a micro-level in soil physicochemical properties further contribute to the better growth of plants.

4.1.5 Plant spread (cm)

The data regarding plant spread of tulsi varieties at 90 days and 150 days after transplanting as influenced by different organic manures and their interactions are presented in Tables 5 and 6.

4.1.5.1 At 90 days after transplanting

4.1.5.1.1 North-South (cm)

The variety Rama tulsi (V_1), significantly produced the higher plant spread in north-south direction (74.75 cm) as compared with variety Krishna tulsi (V_2) (73.49 cm).

Among different organic manures, plant spread was significantly influenced by 100 per cent recommended N applied through vermicompost (78.32 cm) over other organic manures. Significantly, lower plant spread (64.72 cm) was recorded in absolute control (T_1) at 90 days after transplanting.

Table 6. Influence of organic manures on the plant spread (N-S) in tulsi varieties

Treatments	Plant spread (N-S) (cm)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	74.75	60.55
V ₂ : Krishna tulsi	73.49	58.17
Mean	74.12	59.36
S.Em. ±	0.21	0.25
C.D. at 5 %	0.62	0.75
MANURES		
T ₁ : Absolute control	64.72	51.07
T ₂ : Recommended dose of fertilizers	74.27	58.70
T ₃ : 100 % recommended N applied through FYM	76.10	60.97
T ₄ : 100 % recommended N applied through vermicompost	78.32	63.35
T ₅ : 100 % recommended N applied through poultry manure	77.17	62.72
Mean	74.11	59.36
S.Em. ±	0.33	0.40
C.D. at 5 %	0.98	1.19
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	64.95	52.35
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	74.95	59.55
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied FYM	76.85	62.25
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	78.85	64.70
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	78.15	63.92
V ₂ T ₁ : Krishna tulsi with absolute control	64.50	49.80
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	73.60	57.85
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	75.35	59.70
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	77.80	62.00
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	76.20	61.52
Mean	74.12	59.36
S.Em. ±	0.47	0.57
C.D. at 5 %	NS	NS

There was no significant effect on plant spread due to varieties, organic manures and their interaction at 90 days.

4.1.5.1.2 East-West (cm)

The plant spread in the east-west direction was significantly higher (75.33 cm) in the variety Rama tulsi (V_1) as compared with the variety Krishna tulsi (V_2) (74.00 cm).

The plant spread of tulsi varieties was differed due to the application of organic manures. Among the organic manures, significantly higher plant spread (78.66 cm) was recorded under 100 per cent recommended N applied through vermicompost which was *on par* with T_5 (77.77 cm). Significantly, the lower plant spread (66.13 cm) was recorded under absolute control (T_1).

The variation on plant spread was non significant due to the interaction effect of tulsi varieties and organic manures.

4.1.5.2 At 150 days after transplanting

4.1.5.2.1 North-South (cm)

The variety Rama tulsi (V_1) significantly produced the higher plant spread (60.55 cm) as compared to the variety Krishna tulsi (V_2) (58.17 cm).

Plant spread differed significantly among different organic manures adopted. However, higher plant spread (63.35 cm) was documented with the application of 100 per cent recommended N through vermicompost that was *on par* with T_5 (62.72 cm). However, significantly lower plant spread (51.07 cm) was recorded in absolute control (T_1).

The interaction effects were non significant at 150 days after transplanting with respect to plant spread.

4.1.5.2.2 East-West (cm)

A similar pattern was observed at 150 days after transplanting as well. Significantly, higher plant spread (60.75 cm) was recorded in variety Rama tulsi (V_1) as compared to variety Krishna tulsi (V_2) (58.36 cm).

Table 7. Influence of organic manures on the plant spread (E-W) in tulsi varieties

Treatments	Plant spread (E-W) (cm)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	75.33	60.75
V ₂ : Krishna tulsi	74.00	58.36
Mean	74.66	59.55
S.Em. ±	0.34	0.23
C.D. at 5 %	1.01	0.68
MANURES		
T ₁ : Absolute control	66.13	51.87
T ₂ : Recommended dose of fertilizers	74.45	58.45
T ₃ : 100 % recommended N applied through FYM	76.30	60.50
T ₄ : 100 % recommended N applied through vermicompost	78.66	64.08
T ₅ : 100 % recommended N applied through poultry manure	77.77	62.87
Mean	74.66	59.55
S.Em. ±	0.55	0.37
C.D. at 5 %	1.60	1.08
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	67.00	53.27
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	75.20	59.50
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	77.00	61.25
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	79.30	64.92
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	78.15	64.82
V ₂ T ₁ : Krishna tulsi with absolute control	65.27	50.47
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	73.70	57.40
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	75.60	59.75
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	78.02	63.25
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	77.40	60.92
Mean	74.66	59.55
S.Em. ±	0.78	0.52
C.D. at 5 %	NS	NS

Applying different organic manures exerted significant differences in plant spread at 150 days after transplanting. Significantly, 100 per cent recommended N applied through vermicompost recorded higher plant spread (64.08 cm) over other organic manures. While, the minimum plant spread (51.87 cm) was recorded under absolute control (T₁).

There was no significant influence on plant spread due to varieties, organic manures and their interaction.

The plant spread at 90 days and 150 days after harvest was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the plant spread might be due to the genetic makeup of different varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum* and Saraswati *et al.* (2015) in coleus.

The plant spread was significantly influenced by different organic manures. Maximum plant spread at all the stages of growth recorded under vermicompost. Vermicompost had a positive effect on plant spread compared to other organic manures due to the existence of plant growth promoters, like auxins and cytokinins in vermicompost which are responsible for cell division and cell elongation as reported by Loquet *et al.* (1977). Similar findings are observed in Prabu and Arumugam (2013) in mint and Saraswati *et al.* (2015) in coleus.

4.1.6 Chlorophyll content (SPAD readings)

The data pertaining to chlorophyll content of tulsi varieties at 90 days and 150 days after transplanting as influenced by different organic manures and their interactions are displayed in Table 7.

4.1.6.1 At 90 days after transplanting

Chlorophyll content (SPAD values) of tulsi varieties was fluctuated significantly due to the application of different organic manures at 90 days after transplanting. Significantly, higher chlorophyll content (44.72) was observed in variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (39.27).

Table 8. Influence of organic manures on the chlorophyll content (SPAD values) of tulsi varieties

Treatments	Chlorophyll content (SPAD values)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	44.72	40.46
V ₂ : Krishna tulsi	39.27	35.32
Mean	41.99	37.89
S.Em. ±	0.49	0.45
C.D. at 5 %	1.43	1.32
MANURES		
T ₁ : Absolute control	37.24	33.83
T ₂ : Recommended dose of fertilizers	41.57	37.23
T ₃ : 100 % recommended N applied through FYM	42.85	37.95
T ₄ : 100 % recommended N applied through vermicompost	44.27	40.52
T ₅ : 100 % recommended N applied through poultry manure	44.05	39.91
Mean	41.99	37.88
S.Em. ±	0.77	0.71
C.D. at 5 %	2.26	2.09
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	39.24	35.57
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	45.06	40.14
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	46.44	40.86
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	46.52	43.09
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	46.34	42.63
V ₂ T ₁ : Krishna tulsi with absolute control	35.25	32.09
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	38.08	34.32
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	39.25	35.03
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	42.20	37.96
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	41.59	37.19
Mean	41.99	37.88
S.Em. ±	1.10	1.01
C.D. at 5 %	NS	NS

Among different organic manures, higher chlorophyll content (SPAD values) (44.27) was observed in treatment that received 100 per cent recommended N applied through vermicompost, which was *on par* with T₅ (44.05) and T₃ (42.85). Significantly, reduced chlorophyll content (37.24) was observed in absolute control (T₁).

The interaction effect between tulsii varieties and organic manures did not show a significant influence on the chlorophyll content of tulsii at 90 days after transplanting.

4.1.6.2 At 150 days after transplanting

Significantly, higher chlorophyll content (SPAD values) (40.46) was recorded in Rama tulsii (V₁) as compared to Krishna tulsii (V₂) (35.32).

Among the different organic manures, significantly higher chlorophyll content (40.52) was recorded in 100 per cent recommended N applied through vermicompost, that was *on par* with T₅ (39.91). However, significantly lower chlorophyll content (33.83) was recorded in absolute control (T₁).

The interaction effects were found to be non significant at 150 days after transplanting for chlorophyll content (SPAD values).

The chlorophyll content in all the stages of growth till harvest was maximum in Rama tulsii and minimum in Krishna tulsii. It might be due to variation in chlorophyll concentration among two varieties which is controlled mainly by genes acting additively (Herve *et al.*, 2001; Juenger *et al.*, 2005).

The chlorophyll content was significantly influenced by different organic manures. Maximum chlorophyll content at 90 and 150 days of transplanting was recorded under poultry manure and minimum in absolute control. It could be due to increase in N, P and K content with the application of poultry manure. The positive effect of poultry manure on chlorophyll content might be because, poultry manure is rich in nitrogen and nitrogen is a constituent of the chlorophyll molecule. Furthermore, nitrogen is the main constituent of all amino acids in proteins and lipids which act as a structural compound of chloroplast (Badr and Fekry, 1998; Arisha and Bradisi, 1999). Similar findings are observed by Ullah *et al.* (2017) in lettuce.

4.2 Influence of organic manures on yield parameters

4.2.1 Fresh weight of flower head per plant (g)

Results of the fresh weight of flower head per plant of tulsi varieties as influenced by organic manure application and their interactions are showcased in Table 8.

4.2.1.1 At 90 days after transplanting

Tulsi varieties produced a significant difference in fresh weight of flower head per plant. Significantly, Rama tulsi (V_1) recorded the higher fresh weight of flower head per plant (98.90 g) as compared to Krishna tulsi (V_2) (93.09 g).

Application of 100 per cent recommended N through vermicompost produced significantly higher fresh weight of flower head per plant (98.37 g) that was *on par* with T_5 (97.97 g). While, the treatment absolute control (T_1) produced significantly lower fresh weight of flower head per plant (91.82 g).

The interaction effect between tulsi varieties and organic manures on fresh weight of flower head per plant was non-significant.

4.2.1.2 At 150 days after transplanting

A similar trend was observed for 150 days after transplanting as well. Variety Rama tulsi (V_1) recorded the significantly higher fresh weight of flower head per plant (56.17 g) as compared to the variety Krishna tulsi (V_2) (53.39 g).

The flower head fresh weight was significantly increased by the application of different organic manures at 150 days after transplanting as well. Among different organic manures, 100 per cent recommended N applied through vermicompost produced higher fresh weight of flower head per plant (56.92 g) which was *on par* with T_5 (56.45 g). Significantly lower fresh weight of flower head per plant (51.30 g) was recorded under absolute control (T_1).

The variation on fresh weight of flower head per plant was found non-significant due to the interaction effect of tulsi varieties under different organic manures.

Table 9. Influence of organic manures on the fresh weight of flower head per plant in tulsi varieties

Treatments	Fresh weight of flower head per plant (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	98.90	56.17
V ₂ : Krishna tulsi	93.09	53.39
Mean	95.99	54.78
S.Em. ±	0.34	0.24
C.D. at 5 %	1.00	0.70
MANURES		
T ₁ : Absolute control	91.82	51.30
T ₂ : Recommended dose of fertilizers	95.15	53.83
T ₃ : 100 % recommended N applied through FYM	96.65	55.40
T ₄ : 100 % recommended N applied through vermicompost	98.37	56.92
T ₅ : 100 % recommended N applied through poultry manure	97.97	56.45
Mean	95.99	54.78
S.Em. ±	0.54	0.38
C.D. at 5 %	1.58	1.11
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	94.80	52.50
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	98.90	54.90
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	99.40	56.90
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	100.75	58.80
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	100.65	57.75
V ₂ T ₁ : Krishna tulsi with absolute control	88.85	50.10
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	91.40	52.77
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	93.90	53.90
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	96.10	56.10
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	95.20	54.10
Mean	95.99	54.78
S.Em. ±	0.76	0.54
C.D. at 5 %	NS	NS

4.2.2 Dry weight of flower head per plant (g)

The data concerning dry weight of flower head per plant of tulsi varieties as influenced by different organic manures and their interactions are presented in Table 9.

4.2.2.1 At 90 days after transplanting

Significant variation was observed between Rama tulsi and Krishna tulsi with respect to dry weight of flower head per plant. Between the varieties, Rama tulsi (V₁) recorded the higher dry weight of flower head per plant (36.84 g) comparative to Krishna tulsi (V₂) (31.16 g).

The dry weight of flower head per plant of the tulsi crop was significantly influenced by different organic manures at 90 days after transplanting. Among different organic manures, 100 per cent recommended N applied through vermicompost recorded the higher dry weight of flower head per plant (36.50 g) that was *on par* with T₅ (36.20 g) and significantly lower dry weight of flower head per plant (29.80 g) was recorded under absolute control (T₁).

However, the interaction effect between tulsi varieties and organic manures was found non significant at 90 days after transplanting with respect to dry weight of flower head per plant.

4.2.2.2 At 150 days after transplanting

Significantly, higher dry weight of flower head per plant (20.81 g) was recorded in Rama tulsi (V₁) as compared to the variety Krishna tulsi (V₂) (19.57 g) at 150 days after transplanting. The differences among organic manures were recorded significantly varied for flower head dry weight at 150 days of transplanting. 100 per cent recommended N applied through vermicompost recorded significantly higher dry weight of flower head per plant (22.07 g) which was *on par* with T₅ (22.05 g) and the lower dry weight of flower head per plant (17.37 g) was recorded under absolute control (T₁).

The interaction between varieties and organic manures did not have a significant influence on dry weight of flower head per plant of tulsi varieties.

Table 10. Influence of organic manures on the dry weight of flower head per plant in tulsii varieties

Treatments	Dry weight of flower head per plant (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsii	36.84	20.81
V ₂ : Krishna tulsii	31.16	19.57
Mean	34	20.19
S.Em. ±	0.32	0.16
C.D. at 5 %	0.96	0.48
MANURES		
T ₁ : Absolute control	29.80	17.37
T ₂ : Recommended dose of fertilizers	32.85	18.90
T ₃ : 100 % recommended N applied through FYM	34.66	20.56
T ₄ : 100 % recommended N applied through vermicompost	36.50	22.07
T ₅ : 100 % recommended N applied through poultry manure	36.20	22.05
Mean	34	20.19
S.Em. ±	0.52	0.26
C.D. at 5 %	1.51	0.75
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsii with absolute control	31.90	17.55
V ₁ T ₂ : Rama tulsii with recommended dose of fertilizers	35.75	19.65
V ₁ T ₃ : Rama tulsii with 100 % recommended N applied through FYM	37.67	21.15
V ₁ T ₄ : Rama tulsii with 100 % recommended N applied through vermicompost	39.45	22.90
V ₁ T ₅ : Rama tulsii with 100 % recommended N applied through poultry manure	39.45	22.80
V ₂ T ₁ : Krishna tulsii with absolute control	27.70	17.20
V ₂ T ₂ : Krishna tulsii with recommended dose of fertilizers	29.95	18.15
V ₂ T ₃ : Krishna tulsii with 100 % recommended N applied through FYM	31.65	19.97
V ₂ T ₄ : Krishna tulsii with 100 % recommended N applied through vermicompost	33.55	21.30
V ₂ T ₅ : Krishna tulsii with 100 % recommended N applied through poultry manure	32.95	21.25
Mean	34	20.19
S.Em. ±	0.73	0.36
C.D. at 5 %	NS	NS

Flower head fresh weight and flower head dry weight at first and second harvest was higher in Rama tulsi and lower in Krishna tulsi. This variation in flower head fresh weight and dry weight might be due to the genetic makeup of different varieties and their interaction with growing conditions. The above results were found in agreement with Ahl *et al.* (2018) in *Thymus vulgaris*.

Both fresh weight and dry weights of flower head was significantly influenced by different organic manures. Maximum flower head fresh weight and dry weight at the first and second harvest was recorded with vermicompost and minimum in absolute control. Hence, vermicompost showed a positive impact on flower head fresh weight and dry weight per plant. Similar observations were reported by Hadi *et al.* (2015) in chamomile. Vermicompost contains an appreciable amount of organic carbon, nitrogen, phosphorus and potassium. In addition to that, it also contains a good quantity of secondary nutrients of calcium and magnesium. Vermicompost also contains available micronutrients *viz.*, iron, copper, zinc and manganese. In addition to this, vermicompost exercises positive biological effects such as increases in beneficial enzymatic activities, increased populations of beneficial microorganisms or the presence of biologically active plant growth-influencing substances such as plant growth regulators or plant hormones (Grappelli *et al.*, 1987; Tomati and Galli, 1995; Subler *et al.*, 1998) and humic acid (Arancon *et al.*, 2006). These reasons could be attributed to recorded higher flower head fresh weight and dry weight of flower head per plant.

4.2.3 Fresh weight of 1000 leaves

The data on fresh weight of 1000 leaves of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 10.

4.2.3.1 At 90 days after transplanting

The variety Rama tulsi (V₁) recorded significantly higher fresh weight of 1000 leaves (82.39 g) as compared to the variety Krishna tulsi (V₂) (81.02 g).

Significantly, higher fresh weight of 1000 leaves was noticed in the treatment that received 100 per cent recommended N applied through poultry manure (83.31 g) that was

Table 11. Influence of organic manures on fresh weight of 1000 leaves in tulsi varieties

Treatments	Fresh weight of 1000 leaves (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	82.39	71.74
V ₂ : Krishna tulsi	81.02	70.35
Mean	81.70	71.04
S.Em. ±	0.16	0.15
C.D. at 5 %	0.47	0.44
MANURES		
T ₁ : Absolute control	78.37	64.93
T ₂ : Recommended dose of fertilizers	81.88	70.61
T ₃ : 100 % recommended N applied through FYM	82.61	72.53
T ₄ : 100 % recommended N applied through vermicompost	82.34	73.28
T ₅ : 100 % recommended N applied through poultry manure	83.31	73.89
Mean	81.70	71.04
S.Em. ±	0.25	0.24
C.D. at 5 %	0.74	0.70
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	79.15	65.57
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	82.24	71.45
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	83.45	73.12
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	83.08	74.69
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	84.02	73.88
V ₂ T ₁ : Krishna tulsi with absolute control	77.60	64.29
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	81.52	69.77
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	81.77	71.94
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	81.60	73.08
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	82.61	72.67
Mean	81.70	71.04
S.Em. ±	0.36	0.34
C.D. at 5 %	NS	NS

on par with T₃ (82.61 g). Significantly, lower fresh weight of 1000 leaves (78.37 g) was recorded in treatment of absolute control.

The fresh weight of 1000 leaves did not differ significantly due to interaction effects between tulsi varieties and organic manures.

4.2.3.2 At 150 days after transplanting

A similar trend was observed for 150 days after transplanting as well. Significantly, higher fresh weight of 1000 leaves recorded in Rama tulsi (V₁) (71.74 g) as compared to Krishna tulsi (V₂) (70.35 g).

Application of 100 per cent recommended N through poultry manure, recorded significantly higher fresh weight of 1000 leaves (73.89 g) that was *on par* with T₄ (73.28 g). While, absolute control (T₁) produced significantly lower fresh weight of 1000 leaves (64.93 g).

The interaction effects were found to be non significant at 150 days concerning fresh weight of 1000 leaves.

The fresh weight of 1000 leaves at 90 and 150 days after transplanting was maximum in Rama tulsi as compared with Krishna tulsi. The variation in fresh weight of 1000 leaves might be due to the genetical constitution of different varieties and their interaction with growing conditions.

The fresh weight of 1000 leaves was significantly determined by different organic manures. Maximum fresh weight of 1000 leaves at first and second harvest was recorded under poultry manure and minimum in absolute control. Thus, organic manures showed a positive impact on the fresh weight of 1000 leaves. Similar observations were reported by Rahman *et al.* (2014) in pudina. An increase in fresh weight of 1000 leaves might be due to the release of balanced nutrients, especially nitrogen which ensures favourable conditions for the production and elongation of tulsi leaves which might have lead to a maximum of fresh weight of 1000 leaves.

4.2.4 Fresh weight of shoot per plant (g)

The data regarding fresh weight of shoot per plant of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 11 and Figure 4.

4.2.4.1 At 90 days after transplanting

Fresh weight of shoot per plant showed a significant variation between tulsi varieties. Rama tulsi (V_1) produced significantly higher fresh weight of shoot per plant (406.22 g) as compared to the variety Krishna tulsi (V_2) (395.92 g).

Fresh weight of shoot per plant of tulsi crop was significantly influenced by different organic manures at first harvest. Tulsi crop subjected to 100 per cent recommended N applied through vermicompost (T_4), produced remarkably higher fresh weight of shoot per plant (454.90 g) as compared to other manures. Significantly, lower fresh weight of shoot per plant (285.77 g) was recorded in absolute control (T_1).

The interaction effect between tulsi varieties and different organic manures was found significant for the fresh weight of shoot per plant at the first harvest. Significantly, the higher fresh weight of shoot per plant (465.05 g) was noticed in Rama tulsi with 100 per cent recommended N applied through vermicompost (V_1T_4) over other treatment combinations and considerably lower fresh weight of shoot per plant (282.10 g) was noticed in Krishna tulsi with absolute control (V_2T_1).

4.2.4.2 At 150 days after transplanting

A similar trend was seen at 150 days after transplanting as well. Significantly, the higher fresh weight of shoot per plant (199.13 g) was registered in variety Rama tulsi (V_1) as compared to variety Krishna tulsi (V_2) (184.48 g).

Application of 100 per cent recommended N through vermicompost (T_4) had significantly resulted in higher fresh weight of shoot per plant (207.15 g) which was *on par* with T_5 (199.90 g) and T_3 (199.35 g). Substantially, lower fresh weight of shoot per plant (164.47 g) was recorded in absolute control (T_1).

Table 12. Influence of organic manures on fresh weight of shoot per plant in tulsi varieties

Treatments	Fresh weight of shoot per plant (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	406.22	199.13
V ₂ : Krishna tulsi	395.92	184.48
Mean	401.07	191.80
S.Em. ±	1.18	2.27
C.D. at 5 %	3.44	6.64
MANURES		
T ₁ : Absolute control	285.77	164.47
T ₂ : Recommended dose of fertilizers	391.38	188.15
T ₃ : 100 % recommended N applied through FYM	426.97	199.35
T ₄ : 100 % recommended N applied through vermicompost	454.90	207.15
T ₅ : 100 % recommended N applied through poultry manure	446.32	199.90
Mean	401.06	191.80
S.Em. ±	1.86	3.60
C.D. at 5 %	5.45	10.50
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	289.45	164.30
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	393.50	197.85
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	427.95	211.85
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	465.05	216.15
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	455.15	205.50
V ₂ T ₁ : Krishna tulsi with absolute control	282.10	164.65
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	389.27	178.45
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	426.00	186.85
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	444.75	198.15
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	437.50	194.30
Mean	401.07	191.80
S.Em. ±	2.64	5.09
C.D. at 5 %	7.70	NS

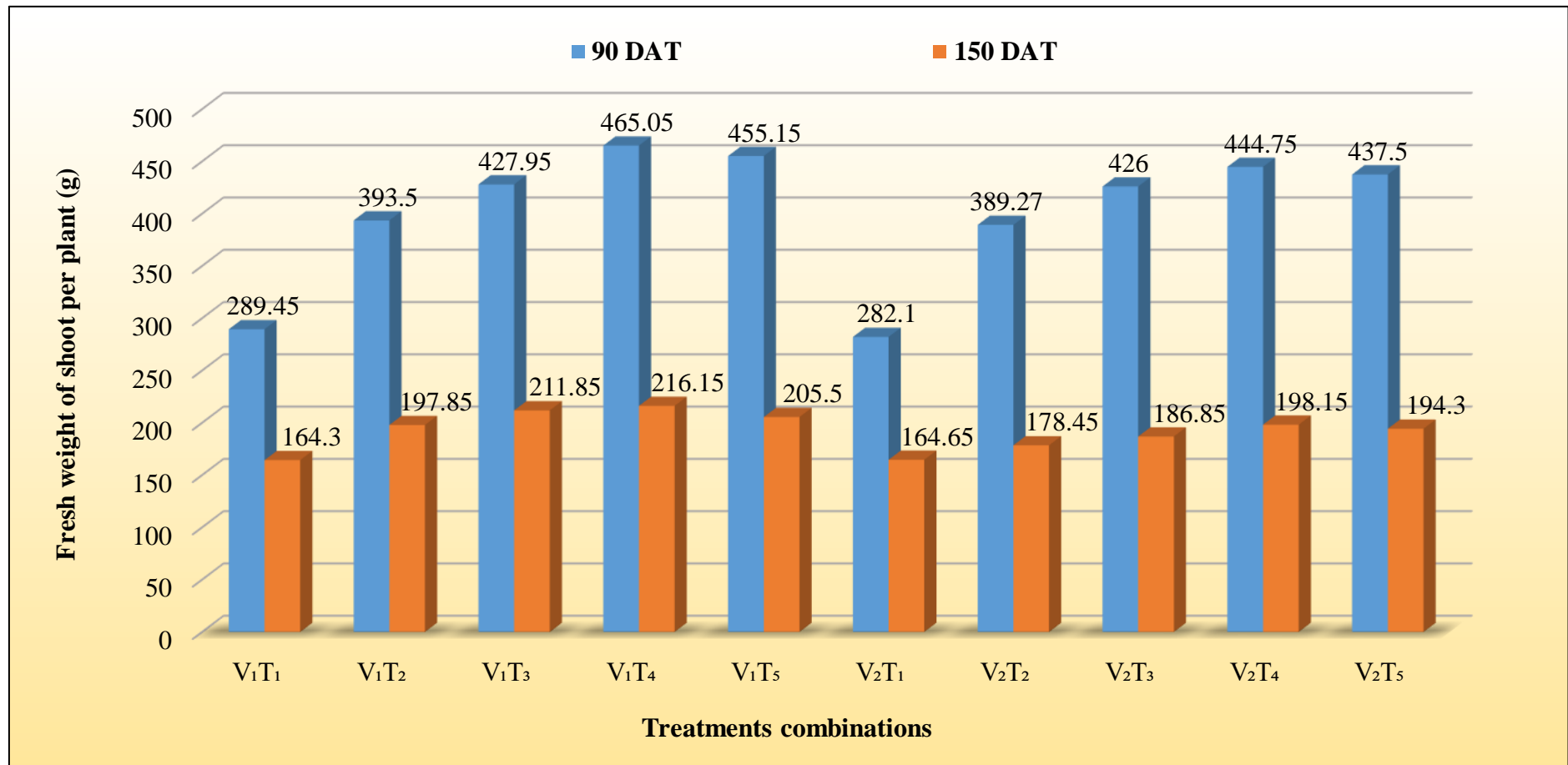


Figure 4. Influence of organic manures on fresh weight of shoot per plant of tulsi varieties

The interaction between tulsi varieties and organic manures did not exhibit a significant influence on the fresh weight of shoot per plant at the second harvest.

The fresh weight of shoot per plant at first and second harvests was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the fresh weight of shoot per plant might be due to the genetic makeup of different varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The fresh weight of shoot per plant was remarkably influenced by different organic manures. Maximum fresh weight of shoot per plant at first and second harvest was recorded with vermicompost and minimum in absolute control. Thus, organic manures showed a positive impact on the fresh weight of shoot per plant. Similar observations were reported by Befrozfar *et al.* (2013) in french basil and Shirkhodaei *et al.* (2014) in coriander. An increase in fresh weight of shoot per plant might be due to increase in growth parameters because of increased nutrient availability, increased beneficial enzymatic activities, increased population of beneficial microorganisms or the presence of biologically active plant growth influencing substances such as plant growth regulators or plant hormones in the vermicompost (Arancon *et al.*, 2006).

4.2.5 Dry weight of shoot per plant (g)

The data related to dry weight of shoot per plant of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 12.

4.2.5.1 At 90 days after transplanting

Rama tulsi (V₁) recorded significantly highest dry weight of shoot per plant (122.80 g) as compared to Krishna tulsi (V₂) (118.41 g).

Application of different organic manures exerted significant differences on dry weight of shoot per plant of tulsi crop at first harvest. Tulsi crop subjected to the 100 per cent recommended N applied through vermicompost (T₄), recorded significantly higher dry weight of shoot per plant (139.50 g) over other organic manures. While, significantly lower dry weight of shoot per plant (84.55 g) was recorded under absolute control (T₁).

Table 13. Influence of organic manures on dry weight of shoot per plant in tulsi varieties

Treatments	Dry weight of shoot per plant (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	122.80	75.77
V ₂ : Krishna tulsi	118.41	71.09
Mean	120.60	73.43
S.Em. ±	0.34	0.72
C.D. at 5 %	1.00	2.11
MANURES		
T ₁ : Absolute control	84.55	63.82
T ₂ : Recommended dose of fertilizers	111.83	72.33
T ₃ : 100 % recommended N applied through FYM	129.94	76.32
T ₄ : 100 % recommended N applied through vermicompost	139.50	78.04
T ₅ : 100 % recommended N applied through poultry manure	137.20	76.63
Mean	120.60	73.42
S.Em. ±	0.54	1.14
C.D. at 5 %	1.59	3.33
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	86.48	63.76
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	114.16	74.94
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	132.64	79.61
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	142.01	81.04
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	138.71	79.49
V ₂ T ₁ : Krishna tulsi with absolute control	82.61	63.88
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	109.50	69.73
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	127.24	73.03
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	136.99	75.04
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	135.70	73.76
Mean	120.60	73.42
S.Em. ±	0.77	1.61
C.D. at 5 %	NS	NS

The interaction effect of tulsi varieties and organic manures on dry weight of shoot per plant was found non significant at first harvest.

4.2.5.2 At 150 days after transplanting

A similar trend was seen at the second harvest as well. Dry weight of shoot per plant of tulsi varieties altered significantly due to the application of different organic manures at second harvest. Significantly, the higher dry weight of shoot per plant (75.77 g) was produced by variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (71.09 g).

Application of 100 per cent recommended N through vermicompost (T₄) resulted in significant increase in dry weight of shoot per plant (78.04 g) which was *on par* with T₅ (76.63 g) and T₃ (76.32 g). Whereas, the absolute control (T₁) produced significantly lower dry weight of shoot per plant (63.82 g).

The interaction effects were found to be non significant at 150 days after transplanting with respect to dry weight of shoot per plant.

The dry weight of shoot per plant at first and second harvest was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the dry weight of shoot per plant might be due to the genetical constitution of varieties and their interaction with growing conditions. The above results were in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The dry weight of shoot per plant was significantly affected by different organic manures. Maximum dry weight of shoot per plant at first and second harvest was recorded in vermicompost and minimum dry weight of shoot per plant in absolute control. Thus, organic manures exhibited a positive impact on dry weight of shoot per plant. Similar observations were reported by Befrozfar *et al.* (2013) in french basil and Shirkhodaei *et al.* (2014) in coriander. An increase in dry weight of shoot per plant might be due to increased fresh weight of shoot per plant in the same treatment.

4.2.6 Fresh weight of herb per plant (g)

The data related to fresh weight of herb per plant of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 13 and Figure 5.

4.2.6.1 At 90 days after transplanting

Fresh weight of herb per plant of tulsi varieties differed appreciably due to applying different organic manures at 90 days after transplanting. Between the two varieties, significantly higher fresh weight of herb per plant (505.12 g) was recorded in variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (489.01 g).

Among the different organic manures, 100 per cent recommended N applied through vermicompost (T₄) recorded significantly higher fresh weight of herb per plant (553.27 g) over other organic manures and considerably lower fresh weight of herb per plant (377.60 g) was recorded under absolute control (T₁).

The interaction effect between tulsi varieties and different organic manures was found significant for the fresh weight of herb per plant at the first harvest. Significantly, the higher fresh weight of herb per plant (565.70 g) was observed in treatment combination of Rama tulsi with 100 per cent recommended N applied through vermicompost (V₁T₄) as compared to rest of the treatment combinations and significantly lower fresh weight of herb per plant (370.95 g) was observed in Krishna tulsi with absolute control (V₂T₁).

4.2.6.2 At 150 days after transplanting

Significantly, higher fresh weight of herb per plant (255.30 g) was recorded in variety Rama tulsi (V₁) compared to variety Krishna tulsi (237.87 g).

Application of 100 per cent recommended N through vermicompost (T₄) had significantly resulted in higher fresh weight of herb per plant (264.07 g) which was *on par* with T₅ (256.35 g) and T₃ (254.75 g). Significantly, lower fresh weight of herb per plant (215.77 g) was recorded in absolute control (T₁).

Table 14. Influence of organic manures on fresh weight of herb per plant in tulsi varieties

Treatments	Fresh weight of herb per plant (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	505.12	255.30
V ₂ : Krishna tulsi	489.01	237.87
Mean	497.06	246.58
S.Em. ±	1.22	2.37
C.D. at 5 %	3.57	6.93
MANURES		
T ₁ : Absolute control	377.60	215.77
T ₂ : Recommended dose of fertilizers	486.53	241.98
T ₃ : 100 % recommended N applied through FYM	523.62	254.75
T ₄ : 100 % recommended N applied through vermicompost	553.27	264.07
T ₅ : 100 % recommended N applied through poultry manure	544.30	256.35
Mean	497.06	246.58
S.Em. ±	1.93	3.75
C.D. at 5 %	5.65	10.96
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	384.25	216.80
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	492.40	252.75
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	527.35	268.75
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	565.70	273.90
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	555.90	264.30
V ₂ T ₁ : Krishna tulsi with absolute control	370.95	214.75
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	480.67	231.22
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	519.90	240.75
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	540.85	254.25
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	532.70	248.40
Mean	497.06	246.58
S.Em. ±	2.74	5.31
C.D. at 5 %	7.99	NS

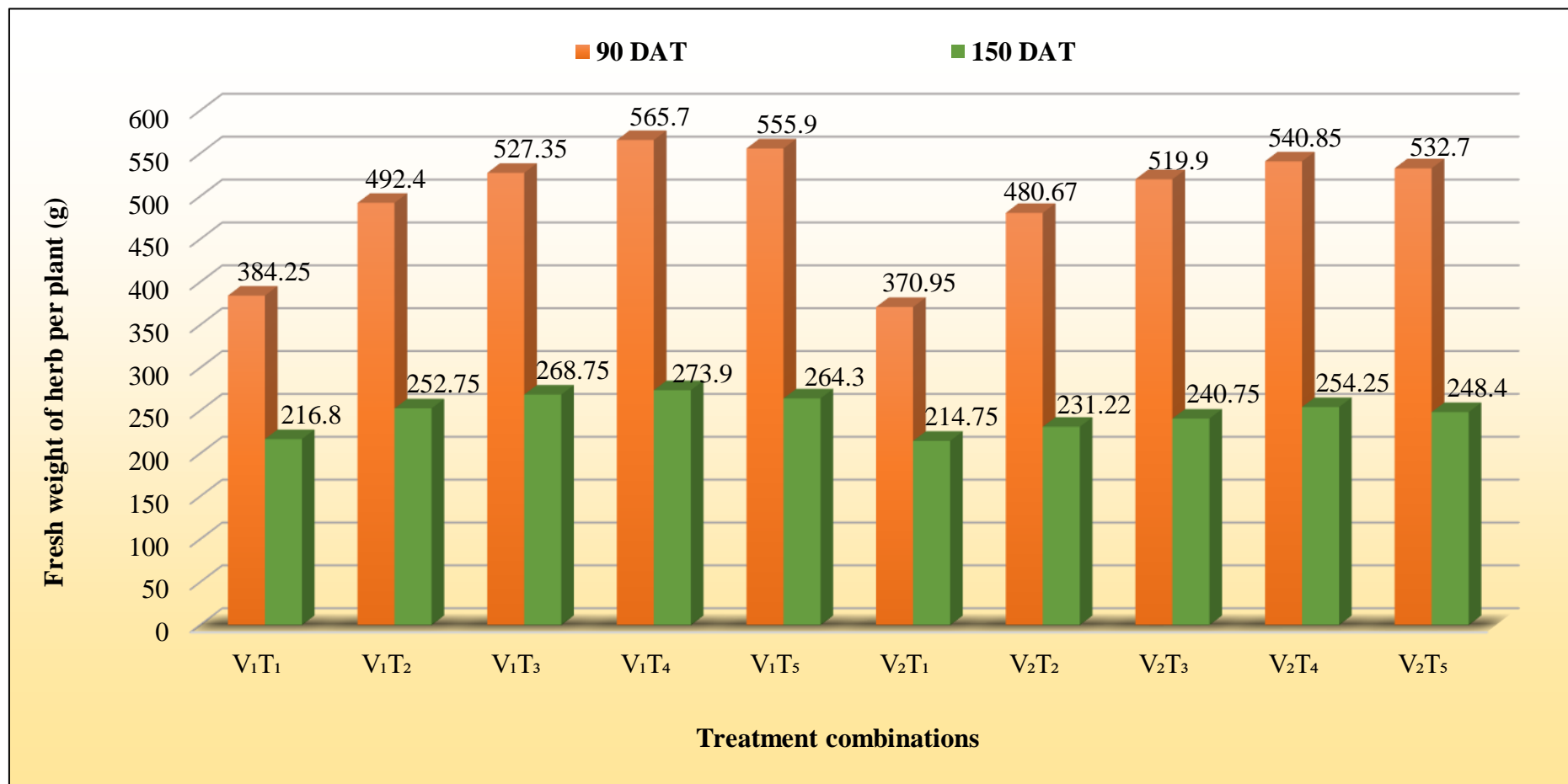


Figure 5. Influence of organic manures on fresh weight of herb per plant of tulsi varieties

However, the interaction effect between tulsi varieties and organic manures was non significant at the second harvest concerning fresh weight of herb per plant.

The fresh weight of herb per plant at 90 and 150 days after transplanting was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the fresh weight of herb per plant might be due to the genetic makeup of distinct varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The fresh weight of herb per plant was significantly influenced by different organic manures. Maximum fresh weight of herb per plant at first and second harvest was recorded under vermicompost and minimum fresh weight of herb per plant was recorded in absolute control. Thus, organic manures showed a positive impact on the fresh weight of herb per plant. Similar observations were reported by Sasikala *et al.* (2016) in lemongrass and Abaszadeh *et al.* (2016) in lavender. An increase in fresh weight of herb per plant might be due to the availability of plant nutrients for a longer period of time at different plant growth stages up to maturity period which helped in root development. Vermicompost improves the physical condition of the soil and provides a better condition for the uptake of nutrients which thereby leads to better growth of the plant. A higher nitrogen and phosphorus content of vermicompost might have a beneficial effect on fresh weight of herb per plant (Gaikwad *et al.*, 2011).

4.2.7 Dry weight of herb per plant (g)

The data regarding dry weight of herb per plant of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 14.

4.2.7.1 At 90 days after transplanting

Dry weight of herb per plant showed significant difference between tulsi varieties. Rama tulsi (V₁) recorded significantly higher dry weight of herb per plant (159.64 g) as compared to the variety Krishna tulsi (V₂) (149.57 g).

Dry weight of herb per plant of tulsi crop was significantly influenced by different organic manures. Tulsi crop subjected to the 100 per cent recommended N applied

Table 15. Influence of organic manures on dry weight of herb per plant in tulsi varieties

Treatments	Dry weight of herb per plant (g)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	159.64	96.58
V ₂ : Krishna tulsi	149.57	90.66
Mean	154.60	93.62
S.Em. ±	0.44	0.71
C.D. at 5 %	1.29	2.08
MANURES		
T ₁ : Absolute control	114.34	81.19
T ₂ : Recommended dose of fertilizers	144.68	91.23
T ₃ : 100 % recommended N applied through FYM	164.60	96.88
T ₄ : 100 % recommended N applied through vermicompost	176.00	100.09
T ₅ : 100 % recommended N applied through poultry manure	173.40	98.70
Mean	154.60	93.61
S.Em. ±	0.70	1.13
C.D. at 5 %	2.04	3.29
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	118.38	81.31
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	149.91	94.59
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	170.32	100.76
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	181.46	103.84
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	178.16	102.39
V ₂ T ₁ : Krishna tulsi with absolute control	110.31	81.09
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	139.45	87.88
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	158.89	93.00
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	170.54	96.34
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	168.65	95.01
Mean	154.60	93.62
S.Em. ±	0.99	1.59
C.D. at 5 %	NS	NS

through vermicompost (T₄), significantly recorded the higher dry weight of herb per plant (176 g) as compared to other organic manures and significantly lower fresh weight of herb per plant (114.34 g) was recorded in absolute control (T₁).

The interaction effect between tulsi varieties and organic manures did not show a significant influence on the dry weight of herb per plant.

4.2.7.2 At 150 days after transplanting

Significantly, the higher dry weight of herb per plant (96.58 g) was produced by variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (90.66 g).

Application of 100 per cent recommended N through vermicompost (T₄) had significantly resulted in higher dry weight of herb per plant (100.09 g) which was *on par* with T₅ (98.70 g) and T₃ (96.88 g). Significantly, lower dry weight of herb per plant (81.19 g) was recorded under absolute control (T₁).

The variation on dry weight of herb per plant at 150 days was shown non significant due to the interaction effect of tulsi varieties and organic manures.

The dry weight of herb per plant at 90 and 150 days after transplanting was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in dry weight of herb per plant might be due to the genetic makeup of distinct varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The dry weight of herb per plant was significantly influenced by different organic manures. Maximum dry herb weight at first and second harvest was recorded under vermicompost and minimum in absolute control. Thus, organic manures showed a positive impact on dry weight of herb per plant. Similar observations were reported by Sasikala *et al.* (2016) in lemongrass and Abaszadeh *et al.* (2016) in lavender. An increase in dry weight of herb per plant might be due to increased fresh weight of herb per plant under the same growing condition and treatment.

4.2.8 Fresh herb yield per plot (kg)

The data concerned with fresh herb yield per plot of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 15.

4.2.8.1 At 90 days after transplanting

The variety Rama tulsi (V_1) produced significantly higher fresh herb yield per plot (17.15 kg) as compared to the variety Krishna tulsi (V_2) (15.14 kg).

Among different organic manures, fresh herb yield per plot was remarkably influenced by 100 per cent recommended N applied through vermicompost at first harvest. Tulsi crop subjected to the 100 per cent recommended N applied through vermicompost (T_4) produced significantly higher fresh herb yield per plot (18.67 kg) over other organic manures. Significantly, lower fresh herb yield per plot (11.82 kg) was produced by absolute control (T_1).

There was no significant influence on fresh herb yield per plot due to varieties, organic manures and their interaction at first harvest.

4.2.8.2 At 150 days after transplanting

Significantly, higher fresh herb yield per plot (11.14 kg) was recorded in variety Rama tulsi (V_1) as compared to variety Krishna tulsi (V_2) (10.31 kg).

Application of 100 per cent recommended N through vermicompost (T_4) had significantly resulted in higher fresh herb yield per plot (12.59 kg) as compared to other organic manures and significantly lower fresh herb yield per plot (8.16 kg) was recorded under absolute control (T_1).

The interaction between tulsi varieties and organic manures did not show a significant influence on fresh herb yield per plot at the second harvest as well.

The fresh herb yield per plot at 150 days after transplanting was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in fresh herb yield per plot might be due to the genetic makeup of different varieties and their interaction with growing

Table 16. Influence of organic manures on fresh herb yield in tulsi varieties

Treatments	Fresh herb yield per plot (kg)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	17.15	11.14
V ₂ : Krishna tulsi	15.14	10.31
Mean	16.14	10.72
S.Em. ±	0.08	0.09
C.D. at 5 %	0.24	0.29
MANURES		
T ₁ : Absolute control	11.82	8.16
T ₂ : Recommended dose of fertilizers	16.22	9.58
T ₃ : 100 % recommended N applied through FYM	16.59	11.23
T ₄ : 100 % recommended N applied through vermicompost	18.67	12.59
T ₅ : 100 % recommended N applied through poultry manure	17.43	12.06
Mean	16.14	10.72
S.Em. ±	0.13	0.15
C.D. at 5 %	0.37	0.45
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	12.82	8.30
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	17.30	10.09
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	17.64	11.61
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	19.63	13.01
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	18.38	12.67
V ₂ T ₁ : Krishna tulsi with absolute control	10.83	8.02
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	15.15	9.07
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	15.55	10.86
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	17.72	12.17
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	16.47	11.45
Mean	16.14	10.72
S.Em. ±	0.18	0.22
C.D. at 5 %	NS	NS



Plate 4. Plot view of Rama tulsi with absolute control and vermicompost

conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The fresh herb yield per plot was positively influenced by different organic manures. Maximum fresh herb yield per plot at final harvest was recorded under vermicompost and minimum in absolute control. Thus, organic manures showed a positive impact on fresh herb yield per plot. Similar observations were reported by Sasikala *et al.* (2016) in lemongrass and Abaszadeh *et al.* (2016) in lavender. An increase in the fresh herb yield per plot might be because vermicompost improves the soil physical condition and promotes organic matter, which in turn produce organic acids, which inhibits particularly IAA oxidase enzyme, resulting in enhancing the promotive effect of auxin-IAA, which has a direct effect on herbage yield (Suresh *et al.*, 2018).

4.2.9 Dry herb yield per plot (kg)

The data with reference to dry herb yield per plot of tulsi varieties at first and second harvest as influenced by different organic manures and their interactions are presented in Table 16.

4.2.9.1 At 90 days after transplanting

Dry herb yield per plot altered significantly due to the application of different organic manures at first harvest. Rama tulsi (V₁) produced significantly higher dry herb yield per plot (7.29 kg) as compared to Krishna tulsi (V₂) (6.71 kg).

Dry herb yield per plot of tulsi crop was significantly affected by the application of different organic manures at the second harvest as well. Tulsi crop subjected to the 100 per cent recommended N applied through vermicompost (T₄), significantly recorded the higher dry herb yield per plot (7.97 kg) over other organic manures. Significantly, lower dry herb yield per plot (5.34 kg) was recorded under absolute control (T₁).

The interaction between tulsi varieties and organic manures did not show a significant influence on dry herb yield per plot.

Table 17. Influence of organic manures on dry herb yield in tulsi varieties

Treatments	Dry herb yield per plot (kg)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	7.29	4.74
V ₂ : Krishna tulsi	6.71	4.52
Mean	7.00	4.63
S.Em. ±	0.05	0.03
C.D. at 5 %	0.15	0.10
MANURES		
T ₁ : Absolute control	5.34	3.75
T ₂ : Recommended dose of fertilizers	6.93	4.22
T ₃ : 100 % recommended N applied through FYM	7.09	4.77
T ₄ : 100 % recommended N applied through vermicompost	7.97	5.31
T ₅ : 100 % recommended N applied through poultry manure	7.67	5.10
Mean	7.00	4.63
S.Em. ±	0.08	0.05
C.D. at 5 %	0.24	0.16
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	5.71	3.80
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	7.23	4.40
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied FYM	7.39	4.90
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	8.22	5.37
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	7.90	5.25
V ₂ T ₁ : Krishna tulsi with absolute control	4.97	3.71
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	6.62	4.05
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	6.78	4.65
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	7.72	5.26
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	7.43	4.95
Mean	6.99	4.63
S.Em. ±	0.11	0.08
C.D. at 5 %	NS	NS



Plate 5. Plot view of Krishna tulsi with absolute control and vermicompost

4.2.9.2 At 150 days after transplanting

A similar trend was seen at the second harvest as well. Significantly, highest dry herb yield per plot (4.74 kg) was recorded in variety Rama tulsi (V_1) and the lower dry herb yield per plot (4.52 kg) was recorded in variety Krishna tulsi (V_2).

100 per cent recommended N applied through vermicompost (T_4) had significantly resulted in higher dry herb yield per plot (5.31 kg) and the lower dry herb yield per plot (3.75 kg) was recorded in absolute control (T_1).

However, the interaction effect between tulsi varieties and organic manures was non significant at second harvest for dry herb yield per plot.

The dry herb yield per plot at 90 and 150 days after transplanting was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the dry herb yield per plot might be due to the genetic makeup of different varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The dry herb yield per plot was significantly influenced by different organic manures. Maximum dry herb yield per plot at first and second harvest was recorded under vermicompost and minimum dry herb yield per plot in absolute control. Thus, organic manures showed a positive impact on dry herb yield per plot. Similar observations were reported by Sasikala *et al.* (2016) in lemongrass and Abaszadeh *et al.* (2016) in lavender. An increase in dry herb yield per plot might be due to the increased fresh herb yield per plot under the same treatment and growing condition.

4.2.10 Fresh herb yield ($t\ ha^{-1}$)

The data on fresh herb yield ($t\ ha^{-1}$) of tulsi varieties at first and second harvest as influenced by tulsi varieties and different organic manures are presented in Table 17.

4.2.10.1 At 90 days after transplanting

Fresh herb yield showed a significant difference between tulsi varieties. Significantly, higher fresh herb yield ($12.76\ t\ ha^{-1}$) was recorded in Rama tulsi (V_1) as compared to Krishna tulsi (V_2) ($11.26\ t\ ha^{-1}$).

Table 18. Influence of organic manures on fresh herb yield in tulsi varieties

Treatments	Fresh herb yield (t ha ⁻¹)		
	90 DAT	150 DAT	Total
VARIETIES			
V ₁ : Rama tulsi	12.76	8.28	21.04
V ₂ : Krishna tulsi	11.26	7.67	18.93
Mean	12.01	7.97	19.93
S.Em. ±	0.06	0.07	0.15
C.D. at 5 %	0.17	0.21	0.47
MANURES			
T ₁ : Absolute control	8.79	6.07	14.86
T ₂ : Recommended dose of fertilizers	12.07	7.13	19.20
T ₃ : 100 % recommended N applied through FYM	12.34	8.36	20.70
T ₄ : 100 % recommended N applied through vermicompost	13.89	9.37	23.26
T ₅ : 100 % recommended N applied through poultry manure	12.96	8.97	21.93
Mean	12.01	7.98	19.99
S.Em. ±	0.09	0.11	0.20
C.D. at 5 %	0.28	0.34	0.63
INTERACTION EFFECT			
V ₁ T ₁ : Rama tulsi with absolute control	9.53	6.17	15.70
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	12.87	7.51	20.38
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	13.12	8.64	21.76
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	14.60	9.68	24.28
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	13.67	9.42	23.09
V ₂ T ₁ : Krishna tulsi with absolute control	8.05	5.97	14.02
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	11.27	6.75	18.02
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	11.56	8.08	19.64
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	13.18	9.05	22.23
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	12.26	8.52	20.78
Mean	12.01	7.97	19.98
S.Em. ±	0.13	0.16	0.24
C.D. at 5 %	NS	NS	NS

Among the different organic manures, application of 100 per cent recommended N through vermicompost (T₄), recorded considerably higher fresh herb yield (13.89 t ha⁻¹) at first harvest over other organic manures and significantly lower fresh herb yield (8.79 t ha⁻¹) was recorded under absolute control (T₁).

The interaction effect of tulsi varieties and organic manures was found to be non significant with respect to fresh herb yield at first harvest.

4.2.10.2 At 150 days after transplanting

A similar trend was seen at the second harvest as well. Significantly, the higher fresh herb yield (8.28 t ha⁻¹) was registered in variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (7.67 t ha⁻¹).

A significant variation among different organic manures was recorded for fresh herb yield. It was significantly higher (9.37 t ha⁻¹) in the treatment of 100 per cent recommended N applied through vermicompost (T₄) over other treatments. Significantly lower fresh herb yield (6.07 t ha⁻¹) was recorded in absolute control (T₁).

The variation on fresh herb yield was found non significant due to the interaction effect of tulsi varieties and organic manures at second harvest as well.

The fresh herb yield at first and second harvest was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the fresh herb yield might be due to the genetic makeup of different varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The fresh herb yield was substantially influenced by different organic manures. Maximum fresh herb yield at first and second harvest was documented under vermicompost and minimum in absolute control. Thus, organic manures showed a positive effect on the fresh herb yield. Similar observations were reported by Sasikala *et al.* (2016) in lemongrass and Abaszadeh *et al.* (2016) in lavender. An increase in the fresh herb yield might be because vermicompost is prepared with the help of earthworms wherein, these earthworms consume a large quantity of organic matter and excretes the casts into the soil which have several plant growth promoters, enzymes rich in plant nutrients, beneficial bacteria and mycorrhiza. Vermicompost is a rich mixture of major

and minor plant nutrients and also due to the role of nitrogen in inducing cell division, cell elongation and cell enlargement. Thus, with better growth and plant development comes better yield.

4.2.11 Dry herb yield (t ha⁻¹)

The data about dry herb yield (t ha⁻¹) of tulsi varieties at first and second harvest as influenced by different organic manures are presented in Table 18.

4.2.11.1 At 90 days after transplanting

The tulsi varieties varied significantly with respect to dry herb yield, where significantly the higher dry herb yield (5.42 t ha⁻¹) was produced by Rama tulsi (V₁) as compared to Krishna tulsi (V₂) (4.99 t ha⁻¹).

The dry herb yield of the tulsi crop was significantly influenced by different organic manure application at the first harvest. Tulsi crop subjected to 100 per cent recommended N applied through vermicompost (T₄) recorded significantly higher dry herb yield (5.93 t ha⁻¹) as compared to other organic manures and significantly lower dry herb yield (3.97 t ha⁻¹) was recorded in absolute control (T₁).

The interaction effect between tulsi varieties and organic manures did not show a significant influence on the dry herb yield (t ha⁻¹).

4.2.11.2 At 150 days after transplanting

The variety Rama tulsi (V₁) recorded significantly, higher dry herb yield (3.53 t ha⁻¹) as compared to variety Krishna tulsi (V₂) (3.36 t ha⁻¹).

The dry herb yield of tulsi varieties was differed due to the application of organic manures at the second harvest. Application of 100 per cent recommended N through vermicompost (T₄) had significantly resulted in higher dry herb yield (3.95 t ha⁻¹) over other organic manures. Significantly, lower dry herb yield (2.79 t ha⁻¹) was produced in the treatment absolute control (T₁).

The interaction effect between tulsi varieties and organic manures on dry herb yield was found non-significant at the second harvest.

Table 19. Influence of organic manures on dry herb yield in tulsi varieties

Treatments	Dry herb yield (t ha ⁻¹)		
	90 DAT	150 DAT	Total
VARIETIES			
V ₁ : Rama tulsi	5.42	3.53	8.95
V ₂ : Krishna tulsi	4.99	3.36	8.35
Mean	5.20	3.44	8.64
S.Em. ±	0.03	0.02	0.08
C.D. at 5 %	0.11	0.07	0.23
MANURES			
T ₁ : Absolute control	3.97	2.79	6.67
T ₂ : Recommended dose of fertilizers	5.15	3.14	8.29
T ₃ : 100 % recommended N applied through FYM	5.27	3.55	8.82
T ₄ : 100 % recommended N applied through vermicompost	5.93	3.95	9.88
T ₅ : 100 % recommended N applied through poultry manure	5.70	3.79	9.49
Mean	5.20	3.44	8.64
S.Em. ±	0.06	0.04	0.09
C.D. at 5 %	0.18	0.12	0.28
INTERACTION EFFECT			
V ₁ T ₁ : Rama tulsi with absolute control	4.24	2.82	7.06
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	5.38	3.27	8.65
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	5.50	3.64	9.14
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	6.11	3.99	10.10
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	5.88	3.91	9.79
V ₂ T ₁ : Krishna tulsi with absolute control	3.70	2.76	6.46
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	4.93	3.02	7.95
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	5.04	3.46	8.50
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	5.75	3.91	9.66
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	5.53	3.68	9.21
Mean	5.20	3.44	8.64
S.Em. ±	0.08	0.05	0.12
C.D. at 5 %	NS	NS	NS

The dry herb yield at first and second was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the dry herb yield might be due to the genetic constitution of different varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The dry herb yield was significantly influenced by different organic manures. Maximum dry herb yield ($t\ ha^{-1}$) at first and second harvest was recorded under vermicompost and minimum dry herb yield ($t\ ha^{-1}$) in absolute control. Thus, organic manures showed a positive influence on dry herb yield. Similar observations were reported by Sasikala *et al.* (2016) in lemongrass and Abaszadeh *et al.* (2016) in lavender. Increase in the dry herb yield might be due to the increased fresh yield under the same treatment and growing conditions.

4.2.12 Oil recovery ($g\ 100g^{-1}$)

The data related to oil recovery ($g\ 100g^{-1}$) of tulsi varieties at the first and second harvest as influenced by different organic manures are presented in Table 19.

4.2.12.1 At 90 days after transplanting

Oil recovery of tulsi varieties differed significantly due to the application of different organic manures. Between the two varieties, significantly higher oil recovery ($0.28\ g\ 100g^{-1}$) was recorded in variety Rama tulsi (V_1) as compared to variety Krishna tulsi (V_2) ($0.26\ g\ 100g^{-1}$).

100 per cent recommended N applied through vermicompost (T_4) had significantly resulted in higher oil recovery ($0.31\ g\ 100g^{-1}$) of tulsi crop that was *on par* with treatment T_5 ($0.30\ g\ 100\ g^{-1}$). While, significantly lower oil recovery ($0.21\ g\ 100g^{-1}$) was recorded under absolute control (T_1).

The interaction effect of tulsi varieties and organic manures was found to be non significant concerning oil recovery ($g\ 100g^{-1}$) at first harvest.

Table 20. Influence of organic manures on oil recovery in tulsi varieties

Treatments	Oil recovery (g 100g ⁻¹)	
	90 DAT	150 DAT
VARIETIES		
V ₁ : Rama tulsi	0.28	0.24
V ₂ : Krishna tulsi	0.26	0.23
Mean	0.27	0.23
S.Em. ±	0.001	0.001
C.D. at 5 %	0.003	0.003
MANURES		
T ₁ : Absolute control	0.21	0.16
T ₂ : Recommended dose of fertilizers	0.26	0.22
T ₃ : 100 % recommended N applied through FYM	0.28	0.23
T ₄ : 100 % recommended N applied through vermicompost	0.31	0.28
T ₅ : 100 % recommended N applied through poultry manure	0.30	0.27
Mean	0.27	0.23
S.Em. ±	0.002	0.002
C.D. at 5 %	0.005	0.004
INTERACTION EFFECT		
V ₁ T ₁ : Rama tulsi with absolute control	0.22	0.16
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	0.27	0.22
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	0.29	0.24
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	0.32	0.29
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	0.31	0.28
V ₂ T ₁ : Krishna tulsi with absolute control	0.20	0.16
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	0.25	0.21
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	0.27	0.22
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	0.30	0.27
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	0.29	0.27
Mean	0.27	0.23
S.Em. ±	0.002	0.002
C.D. at 5 %	NS	NS

4.2.12.2 At 150 days after transplanting

Significantly, higher oil recovery ($0.24 \text{ g } 100\text{g}^{-1}$) was recorded in the variety Rama tulsi (V_1) as compared to the variety Krishna tulsi (V_2) ($0.23 \text{ g } 100\text{g}^{-1}$) at the second harvest.

Application of different organic manures exerted significant differences in oil recovery of tulsi crop. Tulsi crop subjected to the 100 per cent recommended N applied through vermicompost (T_4), significantly recorded the higher oil recovery ($0.28 \text{ g } 100\text{g}^{-1}$) which was *on par* with T_5 ($0.27 \text{ g } 100 \text{ g}^{-1}$). Significantly, lower oil recovery ($0.16 \text{ g } 100\text{g}^{-1}$) was recorded under absolute control (T_1).

The variation on oil recovery ($\text{g } 100\text{g}^{-1}$) showed non significant difference due to the interaction effect of tulsi varieties and organic manures at second harvest as well.

The oil recovery at first and second harvest was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the oil recovery might be due to the genetic makeup of different varieties and their interaction with growing conditions. The above results were found in agreement with Ram *et al.* (2019) in *Ocimum sanctum*.

The oil recovery was considerably influenced by different organic manures. Maximum oil recovery ($\text{g } 100\text{g}^{-1}$) at first and second harvest was recorded under vermicompost and minimum oil recovery ($\text{g } 100\text{g}^{-1}$) in absolute control. Thus, organic manures showed a positive effect on the oil recovery of tulsi varieties. Similar observations were reported by Prabu and Arumugam (2013) in *Mentha arvensis* and Chand *et al.* (2011) in *Pelargonium spp.* Increase in the oil recovery might be due to vermicompost contains most of the plant nutrients such as nitrate, phosphates, exchangeable calcium and soluble potassium and microelements which results in increased essential oil. (Atiyeh *et al.*, 2002; Roy *et al.*, 2010).

4.2.13 Oil yield (kg ha^{-1})

The data regarding oil yield (kg ha^{-1}) of tulsi varieties at first and second harvest as influenced by different organic manures are presented in Table 20.

Table 21. Influence of organic manures on oil yield in tulsi varieties

Treatments	Oil yield (kg ha ⁻¹)		
	90 DAT	150 DAT	Total
VARIETIES			
V ₁ : Rama tulsi	15.71	8.71	24.42
V ₂ : Krishna tulsi	13.59	7.89	21.48
Mean	14.65	8.3	22.95
S.Em. ±	0.14	0.08	0.24
C.D. at 5 %	0.41	0.23	0.69
MANURES			
T ₁ : Absolute control	8.42	4.61	13.03
T ₂ : Recommended dose of fertilizers	13.61	6.96	20.57
T ₃ : 100 % recommended N applied through FYM	14.92	8.23	23.15
T ₄ : 100 % recommended N applied through vermicompost	18.78	11.22	30.00
T ₅ : 100 % recommended N applied through poultry manure	17.50	10.49	27.99
Mean	14.64	8.3	22.94
S.Em. ±	0.22	0.12	0.19
C.D. at 5 %	0.66	0.36	0.60
INTERACTION EFFECT			
V ₁ T ₁ : Rama tulsi with absolute control	9.35	4.73	14.08
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	14.66	7.45	22.11
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	15.96	8.75	24.71
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	20.04	11.59	31.63
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	18.54	11.05	29.59
V ₂ T ₁ : Krishna tulsi with absolute control	7.50	4.48	11.98
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	12.57	6.48	19.05
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	13.87	7.70	21.57
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	17.53	10.86	28.39
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	16.46	9.94	26.4
Mean	14.64	8.3	22.94
S.Em. ±	0.32	0.17	0.20
C.D. at 5 %	NS	NS	NS

4.2.13.1 At 90 days after transplanting

Significantly, higher oil yield (15.71 kg ha⁻¹) was produced by variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (13.59 kg ha⁻¹) at first harvest.

Among different organic manures, tulsi crop subjected to 100 per cent recommended N applied through vermicompost (T₄) produced significantly higher oil yield (18.78 kg ha⁻¹) over other organic manures and significantly lower oil yield (8.42 kg ha⁻¹) was recorded in absolute control (T₁).

The interaction effect of varieties and organic manures was showed non significant on oil yield at first harvest.

4.2.13.2 At 150 days after transplanting

A similar trend was seen at the second harvest as well. Significantly, the higher oil yield (8.71 kg ha⁻¹) was recorded in Rama tulsi (V₁) as compared to Krishna tulsi (7.89 kg ha⁻¹).

The oil yield of tulsi varieties was differed due to the application of organic manures at the second harvest as well. Among different organic manures, significantly higher oil yield (11.22 kg ha⁻¹) was recorded under the treatment that received 100 per cent recommended N through vermicompost (T₄) over other organic manures. Significantly, the lower oil yield (4.61 kg ha⁻¹) was recorded under absolute control (T₁).

The variation between tulsi varieties and organic manures was found non significant due to the interaction effect of varieties and organic manures at the second harvest.

The oil yield at first and second harvest was maximum in Rama tulsi and minimum in Krishna tulsi. The variation in the oil yield might be due to the genetical constitution of different varieties and their interaction with growing conditions.

The oil yield was significantly influenced by different organic manures. Maximum oil yield (kg ha⁻¹) at first and second harvest was recorded under vermicompost and minimum oil yield (kg ha⁻¹) in absolute control. Thus, organic manures showed a positive effect on the oil yield of tulsi varieties. Similar observations were reported by Prabu and Arumugam (2013) in *Mentha arvensis* and Chand *et al.* (2011) in

Pelargonium spp. An increase in oil yield might be due to the increased oil recovery and dry herb yield under the same treatment and growing conditions.

4.3. Available N P K in soil (kg ha⁻¹)

The data related to available nitrogen, phosphorous and potassium in the soil after completion of the experiment is presented in Table 21.

4.3.1 Available Nitrogen (kg ha⁻¹)

There was no significant influence of tulsi varieties on available nitrogen in the soil after harvest. However, higher available nitrogen (155.54 kg ha⁻¹) was recorded in variety Rama tulsi (V₁) as compared to variety Krishna tulsi (V₂) (154.89 kg ha⁻¹).

Among different organic manures, higher available nitrogen in the soil (175.69 kg ha⁻¹) was noticed in the treatment that received 100 per cent recommended N through FYM as compared to rest of the organic manures and appreciably lower available nitrogen in the soil (126.23 kg ha⁻¹) was recorded in absolute control (V₁).

The interaction effect between tulsi varieties and organic manures did not show any significant influence on the available nitrogen in the soil.

The available nitrogen in soil after the final harvest was significantly influenced by different organic manures. Maximum available nitrogen in soil after the final harvest was recorded with farmyard manure and minimum in absolute control. Similar observations were reported by Mansour *et al.* (2017) in french basil and Meena *et al.* (2018) in wheat. An increase in available nitrogen (kg ha⁻¹) might be due to farmyard manure is known to stimulate biological nitrogen fixation in the soil, which might have been responsible for the increase in soil N (Ladha *et al.*, 1989).

4.3.2 Available Phosphorus (kg ha⁻¹)

The variation between tulsi varieties on available phosphorus was found to be non significant. However, higher available phosphorus was recorded in Rama tulsi (27.59 kg ha⁻¹) (V₁) as compared to Krishna tulsi (V₂) (27.21 kg ha⁻¹).

Table 22. Influence of organic manures on available N P K in the soil after final harvest of tulsi varieties

Treatments	Available N P K in soil (kg ha ⁻¹)		
	N	P	K
VARIETIES			
V ₁ : Rama tulsi	155.54	27.59	207.61
V ₂ : Krishna tulsi	154.89	27.21	206.45
Mean	155.21	27.4	207.03
S.Em. ±	0.22	0.14	0.41
C.D. at 5 %	NS	NS	NS
MANURES			
T ₁ : Absolute control	126.23	16.18	154.15
T ₂ : Recommended dose of fertilizers	141.06	22.80	188.10
T ₃ : 100 % recommended N applied through FYM	175.69	27.72	228.80
T ₄ : 100 % recommended N applied through vermicompost	166.03	34.83	229.65
T ₅ : 100 % recommended N applied through poultry manure	167.06	35.47	234.44
Mean	155.21	27.4	207.02
S.Em. ±	0.35	0.23	0.65
C.D. at 5 %	1.04	0.67	1.91
INTERACTION EFFECT			
V ₁ T ₁ : Rama tulsi with absolute control	126.31	16.34	154.29
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	141.45	23.03	188.20
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	175.93	27.87	230.55
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	166.39	34.98	230.16
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	167.61	35.73	234.87
V ₂ T ₁ : Krishna tulsi with absolute control	126.15	16.01	154.02
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	140.66	22.58	188.00
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	175.45	27.57	227.04
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	165.68	34.68	229.14
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	166.51	35.20	234.04
Mean	155.21	27.39	207.03
S.Em. ±	0.50	0.32	0.93
C.D. at 5 %	NS	NS	NS

Application of 100 per cent recommended N through poultry manure registered significantly higher available phosphorus (35.47 kg ha⁻¹) that was *on par* with T₄ (34.83 kg ha⁻¹). While, considerably lower available phosphorus in soil (16.18 kg ha⁻¹) was recorded in absolute control (V₁).

The interaction effects caused due to varieties and organic manures on available phosphorus content were found non significant.

The available phosphorous in soil after the final harvest was significantly influenced by different organic manures. Maximum available phosphorous in soil after the final harvest was recorded with poultry manure and minimum in absolute control. Similar observations were reported by Zaman *et al.* (2015) in stevia and Kamal *et al.* (2012) in Mango. An increase in available phosphorous (kg ha⁻¹) might be due to the higher nutrient contents of poultry manure compared to other organic amendments.

4.3.3 Available Potassium (kg ha⁻¹)

There was no significant influence of tulsii varieties on available potassium in the soil after harvest. However, variety Rama tulsii (V₁) recorded significantly higher available potassium (207.61 kg ha⁻¹) as compared to variety Krishna tulsii (V₂) (206.45 kg ha⁻¹).

Available potassium in soil differed significantly among different organic manures adopted. However, significantly higher available potassium in soil (234.44 kg ha⁻¹) was recorded with the application of 100 per cent recommended N through poultry manure over other organic manures. Significantly, lower available potassium in soil (154.15 kg ha⁻¹) was recorded in absolute control (T₁).

There was no significant influence on available potassium in the soil due to varieties, organic manures and their interaction.

The available potassium in soil after the final harvest was remarkably influenced by different organic manures. Maximum available potassium in the soil after the final harvest was recorded with poultry manure and minimum in absolute control. Thus, organic manures showed a positive impact on the available potassium in the soil. Similar observations were reported by Zaman *et al.* (2015) in stevia and Kamal *et al.* (2012) in

Mango. An increase in available potassium (kg ha^{-1}) might be due to higher nutrient content of poultry manure compared to other amendments.

4.4 Nutrient uptake by plants (kg ha^{-1})

Nitrogen, phosphorous and potassium uptake by tulsi crop as determined by different organic manures are presented in Tables 22.

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

Significantly, higher nitrogen uptake (97.23 kg ha^{-1}) was recorded in Rama tulsi (V_1) and reduced nitrogen uptake (93.64 kg ha^{-1}) was recorded in Krishna tulsi (V_2).

Among different organic manures, significantly higher nitrogen uptake ($113.98 \text{ kg ha}^{-1}$) was recorded in the treatment that received 100 per cent recommended N through vermicompost (T_4) as compared to rest of the organic manures and significantly reduced nitrogen uptake (67.60 kg ha^{-1}) was recorded in absolute control (T_1).

There was no significant influence on nitrogen uptake due to varieties, organic manures and their interaction.

Maximum nitrogen uptake was recorded in Rama tulsi, while least nitrogen uptake was recorded in Krishna tulsi. The variation in the nitrogen uptake might be due to the ability of Rama tulsi to draw more nutrients from the soil than Krishna tulsi.

The nitrogen uptake was significantly influenced by different organic manures. Maximum nitrogen uptake was recorded in treatment that received vermicompost and minimum in absolute control. Thus, organic manures showed a positive impact on nitrogen uptake. Similar observations were reported by Zaman *et al.* (2015) in stevia and Sindhu *et al.* (2016) in *Indigofera tinctoria*. Increased nitrogen uptake might be related to higher biomass yield. This might be due to higher dry herb yield was harvested from the same treatment. Because nutrient uptake was calculated from their concentrations and corresponding dry herb yield.

Table 23. Influence of organic manures on nutrient uptake by tulsi varieties

Treatments	Nutrient uptake (kg ha ⁻¹)		
	N	P	K
VARIETIES			
V ₁ : Rama tulsi	97.23	27.24	109.84
V ₂ : Krishna tulsi	93.64	25.75	107.46
Mean	95.43	26.49	108.65
S.Em. ±	0.31	0.13	0.32
C.D. at 5 %	0.91	0.37	0.95
MANURES			
T ₁ : Absolute control	67.60	20.19	76.94
T ₂ : Recommended dose of fertilizers	83.32	24.41	95.20
T ₃ : 100 % recommended N applied through FYM	99.85	27.57	117.63
T ₄ : 100 % recommended N applied through vermicompost	113.98	30.39	127.09
T ₅ : 100 % recommended N applied through poultry manure	112.43	29.92	126.37
Mean	95.43	26.49	108.64
S.Em. ±	0.49	0.20	0.51
C.D. at 5 %	1.44	0.59	1.50
INTERACTION EFFECT			
V ₁ T ₁ : Rama tulsi with absolute control	69.49	20.65	78.48
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	84.73	24.94	96.30
V ₁ T ₃ : Rama tulsi with 100 % recommended N Applied through FYM	101.17	28.41	118.93
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	116.13	31.38	127.91
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	114.65	30.82	127.57
V ₂ T ₁ : Krishna tulsi with absolute control	65.71	19.72	75.40
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	81.91	23.87	94.11
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	98.54	26.74	116.34
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	111.84	29.40	126.27
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	110.22	29.01	125.17
Mean	95.43	26.49	108.64
S.Em. ±	0.69	0.29	0.72
C.D. at 5 %	NS	NS	NS

4.4.2 Phosphorous uptake (kg ha⁻¹)

Phosphorous uptake showed a significant difference between tulsi varieties. Between the varieties, significantly higher phosphorous uptake (27.24 kg ha⁻¹) was recorded in Rama tulsi (V₁) as compared to Krishna tulsi (V₂) (25.75 kg ha⁻¹).

Application of organic manures exerted significant differences on phosphorous uptake by tulsi crop. Among different organic manures, significantly higher phosphorous uptake (30.39 kg ha⁻¹) was recorded in 100 per cent recommended N applied through vermicompost (T₄) that was *on par* with T₅ (29.92 kg ha⁻¹). Significantly, lower phosphorous uptake (20.19 kg ha⁻¹) was recorded in absolute control (T₁).

The interaction effect between tulsi varieties and organic manures on phosphorous uptake was found non significant.

Maximum phosphorous uptake was recorded in Rama tulsi, while the least phosphorous uptake was recorded in Krishna tulsi. The variation in the phosphorous uptake might be due to the ability of Rama tulsi to draw more nutrients from the soil than Krishna tulsi.

The phosphorous uptake was appreciably influenced by different organic manures. Maximum phosphorous uptake was recorded under vermicompost and minimum in absolute control. Thus, organic manures showed a positive effect on phosphorous uptake. Similar observations were reported by Zaman *et al.* (2015) in stevia and Sindhu *et al.* (2016) in *Indigofera tinctoria*. Increased phosphorous uptake might be due to increase in solubilization of phosphorus either by microorganism activation with excretion of organic acids such as citric, glutamic, tartaric, succinic, lactic, oxalic, malic and fumaric acids or by greater phosphatase activity in soil (Zaman *et al.*, 2015).

4.4.3 Pottasium uptake (kg ha⁻¹)

Rama tulsi (V₁) recorded significantly higher potassium uptake (109.84 kg ha⁻¹) as compared to Krishna tulsi (V₂) (107.46 kg ha⁻¹).

Application of 100 per cent recommended N through vermicompost recorded significantly higher potassium uptake (127.09 kg ha⁻¹) which was *on par* with T₅ (126.37

kg ha⁻¹) and significantly lower potassium uptake (76.94 kg ha⁻¹) was recorded in absolute control (T₁).

The variation in potassium uptake was found non significant due to the interaction effect of tulsi varieties and organic manures.

Maximum potassium uptake was recorded in Rama tulsi, while the least potassium uptake was recorded in Krishna tulsi. The variation in the potassium uptake might be due to the ability of Rama tulsi to draw more nutrients from the soil than Krishna tulsi.

The potassium uptake was significantly influenced by different organic manures. Maximum potassium uptake was recorded in treatment that received vermicompost and minimum in absolute control. Thus, organic manures showed a positive impact on potassium uptake. Similar observations were reported by Zaman *et al.* (2018) in stevia and Sindhu *et al.* (2016) in *Indigofera tinctoria*. Increased potassium uptake might be related to higher biomass yield. This might be due to higher dry herb yield was harvested from the same treatment. Because the nutrient uptake was calculated from their concentrations and corresponding dry herb yield.

4.5 Economics

The observations recorded on the cost of cultivation, gross income, net income and B: C ratio of tulsi varieties as influenced by different organic manures are furnished along with the results and discussed below.

4.5.1 Cost of cultivation (Rs. ha⁻¹)

The cost of cultivation for different agricultural inputs and intercultural operations has shown significant difference and the same is presented in Table 23 and Figure 6.

Higher cost of cultivation was recorded in the treatment that received 100 per cent recommended N through poultry manure (88,810 Rs. ha⁻¹) followed by 100 per cent recommended N applied through vermicompost (88,360 Rs. ha⁻¹). While the lower cost of cultivation was recorded in absolute control (70,450 Rs. ha⁻¹).

Table 24. Influence of organic manures on Economics of organic cultivation of tulsi varieties

Treatments	Dry herb yield (t ha⁻¹)	Treatment cost (Rs. ha⁻¹)	Gross returns (Rs. ha⁻¹)	Net returns (Rs. ha⁻¹)	B: C ratio
V ₁ T ₁ : Rama tulsi with absolute control	7.06	70,450	2,11,800	1,41,350	3.00
V ₁ T ₂ : Rama tulsi with recommended dose of fertilizers	8.65	77,905	2,59,500	1,81,595	3.33
V ₁ T ₃ : Rama tulsi with 100 % recommended N applied through FYM	9.14	83,350	2,74,200	1,90,850	3.28
V ₁ T ₄ : Rama tulsi with 100 % recommended N applied through vermicompost	10.1	88,360	3,03,000	2,14,640	3.42
V ₁ T ₅ : Rama tulsi with 100 % recommended N applied through poultry manure	9.79	88,810	2,93,700	2,04,890	3.30
V ₂ T ₁ : Krishna tulsi with absolute control	6.46	70,450	1,93,800	1,23,350	2.75
V ₂ T ₂ : Krishna tulsi with recommended dose of fertilizers	7.95	77,905	2,38,500	1,60,595	3.06
V ₂ T ₃ : Krishna tulsi with 100 % recommended N applied through FYM	8.5	83,350	2,55,000	1,71,650	3.05
V ₂ T ₄ : Krishna tulsi with 100 % recommended N applied through vermicompost	9.66	88,360	2,89,800	2,01,440	3.27
V ₂ T ₅ : Krishna tulsi with 100 % recommended N applied through poultry manure	9.21	88,810	2,76,300	1,87,490	3.11

Note: Dry herb rate : Rs. 30 per kilogram

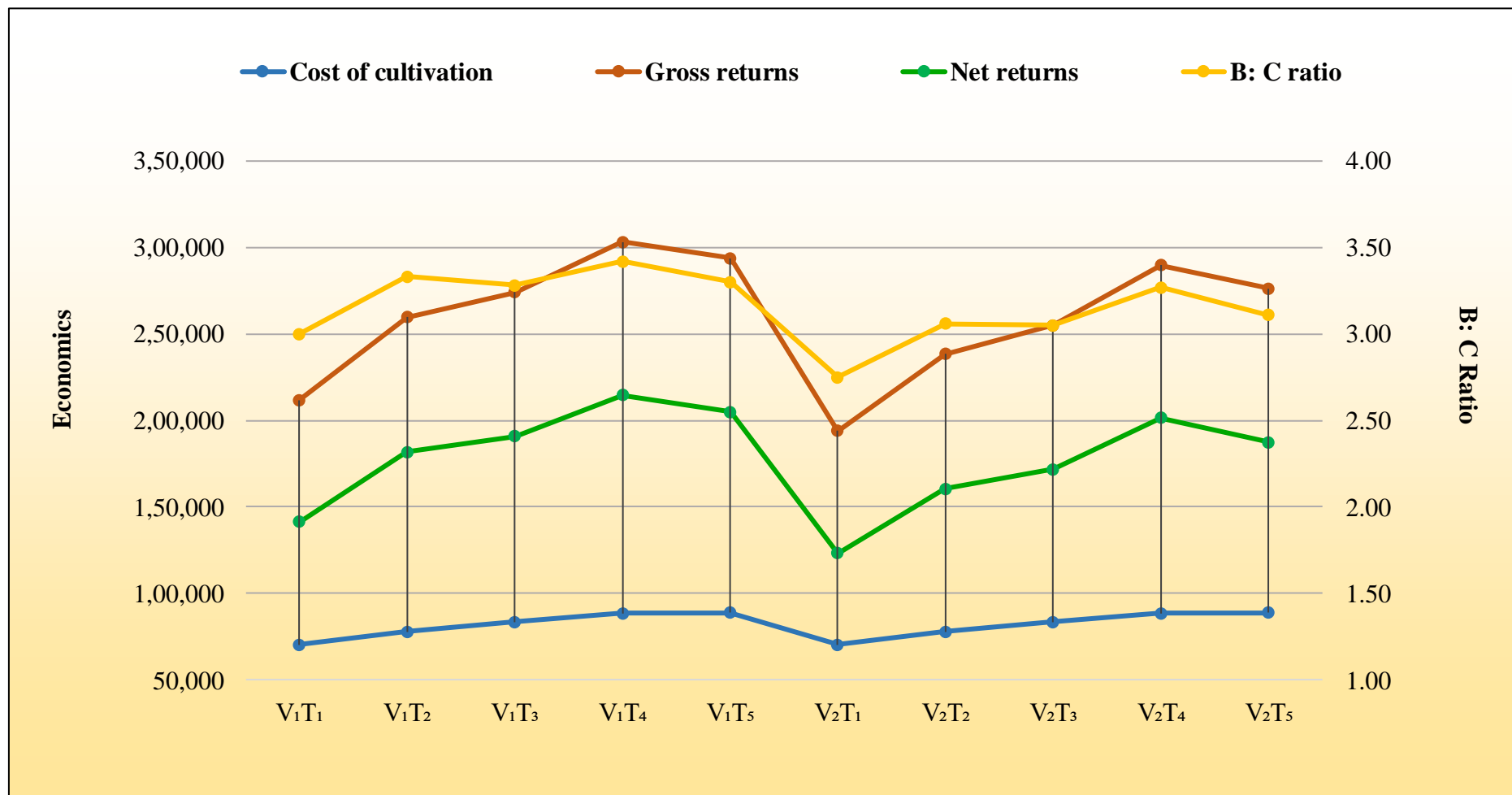


Figure 6. Influence of organic manures on economics of tulsi varieties

4.5.2 Gross returns (Rs. ha⁻¹)

Gross returns were obtained by multiplying the market rate of dry herbage yield with the total yield per hectare. This has exhibited significant differences among different organic manures and tulsii varieties as furnished in Table 23.

Higher gross returns (3,03,000 Rs. ha⁻¹) were obtained in the treatment of Rama tulsii with 100 per cent recommended N applied through vermicompost, followed by Rama tulsii with 100 per cent recommended N applied through poultry manure (2,93,700 Rs. ha⁻¹). While, the lower gross returns were obtained in Krishna tulsii with absolute control (1,93,800 Rs. ha⁻¹).

4.5.3 Net returns (Rs. ha⁻¹)

Net returns were obtained by subtracting the cost of cultivation from gross returns and this has shown significant difference among different organic manures and tulsii varieties. The same is furnished in Table 23 and Figure 6.

Significantly, higher net returns were obtained in the treatment of Rama tulsii with 100 per cent recommended N applied through vermicompost (2,14,640 Rs. ha⁻¹) followed by the treatment of Rama tulsii with 100 per cent recommended N applied through poultry manure (2,04,890 Rs. ha⁻¹). However, lower net returns were obtained in Krishna tulsii with absolute control (1,23,350 Rs. ha⁻¹).

4.5.4 Benefit-cost (B: C) ratio

Benefit cost ratio was obtained by dividing the cost of cultivation from gross returns, this significantly differed among the different organic manures and tulsii varieties. The details are provided in Table 23 and Figure 6.

Significantly, the higher benefit-cost ratio (3.42) was recorded in the treatment of Rama tulsii with 100 per cent recommended N applied through vermicompost followed by Rama tulsii with recommended dose of fertilizers (3.33) and lower benefit-cost ratio was obtained in Krishna tulsii with absolute control (2.75).

The higher benefit-cost ratio was obtained in Rama tulsii with 100 per cent recommended N applied through vermicompost. This was mainly because of higher gross

returns. Similar results were reported by Hasan *et al.* (2018) in *Daucus Carota* and Pandey *et al.* (2020) in turmeric.

Summary and Conclusions

V. SUMMARY AND CONCLUSION

The present investigation on “Studies on growth, yield and quality of tulsi (*Ocimum sanctum* L.) as influenced by organic manures” was conducted during 2019-20 in the College of Agriculture, Raichur of Karnataka state in India. The experiment had ten treatment combinations involving, two varieties (Rama tulsi and Krishna tulsi) and five different sources of nitrogen (Absolute control, 100 % recommended nitrogen applied through inorganic fertilizers, 100 % recommended nitrogen applied through farmyard manure, 100 % recommended nitrogen applied through vermicompost, 100 % recommended nitrogen applied through poultry manure). The experiment had four replications and the design adopted was Factorial Randomized Block Design.

The results obtained under study affirmed that the treatments under study had a significant influence on the growth, yield and quality of tulsi crop. The results obtained in the study have been summarized below.

1. Between the varieties, Rama tulsi has performed significantly better than Krishna tulsi.
2. Among different organic manures, significantly better growth and development were noticed in treatment that received 100 per cent recommended nitrogen through vermicompost.
3. Between the two varieties studied, Rama tulsi recorded significantly higher values for growth, yield and quality parameters, that include plant height (82.99 cm), number of branches per plant (22.33), leaf area (6575 cm² plant⁻¹), leaf area index (2.42), plant spread in north-south direction (74.75 cm), plant spread in east-west direction (75.33 cm), chlorophyll content (SPAD readings) (44.72), flower head fresh weight per plant (98.90 g), flower head dry weight per plant (36.84 g), 1000 fresh leaf weight (82.39 g), fresh shoot weight per plant (406.22 g), dry shoot weight per plant (122.80 g), fresh herb weight per plant (505.12 g), dry herb weight per plant (159.64 g), fresh herb yield per plot (17.15 kg), dry herb yield per plot (7.29 kg), fresh herb yield (12.76 t ha⁻¹), dry herb yield (5.42 t ha⁻¹), oil recovery (0.28 g 100g⁻¹), oil yield (15.71 kg ha⁻¹), available nitrogen in soil (155.54 kg ha⁻¹), available phosphorous in soil (27.59 kg ha⁻¹), available

potassium in soil (207.61 kg ha⁻¹), nitrogen uptake (97.23 kg ha⁻¹), phosphorous uptake (27.24 kg ha⁻¹) and potassium uptake (109.84 kg ha⁻¹).

4. Among the different organic manures, significantly higher growth, yield and quality parameters were recorded when 100 per cent recommended N was applied through vermicompost, *i.e.* plant height (85.95 cm), leaf area (7181 cm² plant⁻¹), leaf area index (2.64), plant spread of north-south (78.32 cm), plant spread of east-west (78.66 cm), chlorophyll content (SPAD values) (44.27), flower head fresh weight per plant (98.37 g), flower head dry weight per plant (36.50 g), fresh shoot weight per plant (454.90 g), dry shoot weight per plant (139.50 g), fresh herb weight per plant (553.27 g), dry herb weight per plant (176 g), fresh herb yield per plot (18.67 kg), dry herb yield per plot (7.97 kg), fresh herb yield (13.89 t ha⁻¹), dry herb yield (5.93 t ha⁻¹), oil recovery (0.31 g 100g), oil yield (18.78 kg ha⁻¹), nitrogen uptake (113.98 kg ha⁻¹), phosphorus uptake (30.39 kg ha⁻¹) and potassium uptake (127.09 kg ha⁻¹). When 100 per cent recommended N was applied through poultry manure, higher number of branches (23.80), 1000 fresh leaf weight (83.31 g), available soil phosphorus (35.47 kg ha⁻¹) and available soil potassium (234.44 kg ha⁻¹) was recorded. Likewise, 100 per cent recommended N applied through farmyard manure recorded higher values for available soil nitrogen (175.69 kg ha⁻¹).
5. Between different treatment combinations (interaction between tulsii varieties and different organic manures), significantly higher growth and yield were recorded by Rama tulsii with 100 per cent recommended N applied through vermicompost. The recorded growth and yield parameters were leaf area (7267 cm² plant⁻¹), leaf area index (1.18), fresh shoot weight per plant (465.05 g) and fresh herb weight per plant (565.70 g). Higher gross returns (1,51,500 Rs. ha⁻¹), net returns (75,890 Rs. ha⁻¹) and benefit-cost ratio (2.00) were recorded in treatment consisting of Rama tulsii with 100 per cent recommended N applied through vermicompost.
6. The interaction between varieties and different organic manures did not reveal a significant difference on plant height, number of branches per plant, plant spread, chlorophyll content (SPAD readings), flower head fresh weight per plant, flower head dry weight per plant, 1000 fresh leaf weight, dry shoot weight per plant, dry herb weight per plant, fresh herb yield per plot, dry herb yield per plot, fresh herb

yield, dry herb yield, oil recovery, oil yield, nutrient uptake, available nitrogen, available phosphorous and available potassium in the soil. This indicated that the performance of the varieties with different organic manures was not static and nonresponsive and rather adaptable. The reason for non-significant values might be attributed to less effect of a single factor and the inconspicuous interaction effect. The response mainly depends on the crop growth period and growing conditions the prevailed.

Conclusion

From the results of the study it is inferred that Rama tulsi (V₁) performed better considering morpho-physiological attributes and by registering maximum mean values for various parameters in comparison to Krishna tulsi (V₂). Between the varieties, Rama tulsi showed better response to the application of vermicompost than Krishna tulsi.

Different organic manures showed variable results on different attributes. Results revealed that most of the parameters registered higher values with the application of vermicompost. Considering all the parameters it may be concluded that, 100 per cent recommended N applied through vermicompost increased the morpho-physiological characters of tulsi varieties leading to increased yield compared to other organic manures. Hence, 100 per cent recommended N applied through vermicompost was found to be beneficial for proper growth and development of tulsi varieties.

Future line of work

1. Studies can be taken up foliar sprays of micronutrients and growth regulators on *Ocimum sanctum*.
2. *Ocimum* has many species, among them; *Ocimum basilicum* has immense medicinal value. So studies can be taken for the influence of organic manures on the growth and oil yield of *Ocimum basilicum*.

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Appendices

APPENDIX-1

Mean monthly meteorological data of the experimental field for the year 2019-20

Month	Rainfall (mm)	Relative humidity morning (%)	Relative humidity evening (%)	Maximum temperature (°C)	Minimum temperarure (°C)
January	10	69.5	41.3	30	16.3
February	0	62.8	42.2	31	20.4
March	0	53.8	23.5	38.1	23.9
April	13.5	50	19	40.8	26.2
May	10.4	52.8	19	41.4	27.6
June	67	75.1	37.8	37.3	25.2
July	79.6	81.8	47.3	34.6	22.7
August	46	83.8	48.8	32.8	23.7
September	312.2	89.1	59.1	31.7	23.1
October	130.4	91.3	64	30.6	22.8
November	0	85.9	50.2	31.1	20.8
December	0	83.2	47	29.9	19
January	0	78.5	37.2	31.6	19.1
February	0	70.1	28.9	33.2	20.1
March	0	58	25.6	36.4	23.8

APPENDIX-2

Fixed cost and expenditure report of organic cultivation of tulsi

Sr. No.	Particulars	Cost of cultivation (Rs/ha)
1.	Input cost:	
	Seeds: 300 g @ 300 Rs/100 g	Rs. 900
	FYM: 29.8 t @ 500 Rs/ton	Rs. 14,900
	Vermicompost: 11.94 t @ 1,500 Rs/ton	Rs. 17,910
	Poultry manure: 9.18 t @ 2,000 Rs/ton	Rs. 18,360
2.	Fertilizer cost:	
	Urea: 260.9 kg @ 6.5 Rs/kg	Rs. 1,695
	SSP: 468.8 kg @ 8.34 Rs/kg	Rs. 3,910
	MOP: 100 kg @ 18.5 Rs/kg	Rs. 1,850
3.	Plant protection cost:	
	Neem seed kernal oil: 1 L @ 250 Rs/L	Rs. 1,250
4.	Labour cost:	
	Tractor	Rs. 4,000
	Layout and land Preparation	Rs. 6,000
	Manure application	Rs. 6,000
	Sowing	Rs. 2,500
	Transplanting	Rs. 6,000
	Spraying: Neem seed kernal extract	Rs. 5,000
	Irrigation	Rs. 8,000
	Weeding	Rs. 10,000
	Harvesting	Rs. 10,800
	Miscellaneous	Rs. 10,000
5.	Rate of dry herbage	Rs. 30/kg