Effect of organic manures and foliar application on growth, yield and nutrient uptake of Kalmegh(*Andrographis paniculata* Nees.)

Abstract

A field experiment was carried out to study the effect of organic manures and foliar application of organics on growth and yield of Kalmegh at the Department of Horticulture, Faculty of Agriculture, Annamalai University to find out the suitable organic inputs and foliar organics for better growth and yield of Kalmegh. The experiment was laid out in a Randomized Block Design with three replication and twelve treatments comprising of a different combination of (i) basal organics *viz.,* Farm Yard Manure, Vermicompost and Pressmud (ii) foliar spray of organics *viz.,* panchagavya and fish amino acid and untreated control. Among the twelve treatments, the plants which received Vermicompost 5 t ha^{-1} + fish amino acid at 3% expressed higher values for the growth parameters *viz.,* plant height (69.80 cm), number of branches (25.13), number of leaves per plant (140.87). Physiological parameters *viz.,* leaf area $plant^{-1}$ (6.78), total dry matter production $plant^{-1}$ (15.86 g $plant^{-1}$). Yield parameters *viz.,* fresh herbage yield $plant^{-1}$ (42.74 g $plant^{-1}$) and dry herbage yield $plant^{-1}$ (14.24 g $plant^{-1}$). Nutrient uptake, N (38.97 Kg ha^{-1}), P (6.87 Kg ha^{-1}) and K (84.23 kg ha^{-1}).

Keywords:Kalmegh, Organic Manures, Vermicompost, Panchagavya, Growth and Yield

Introduction

"Kalmegh (*Andrographis paniculata* Nees.) otherwise known as King of bitters, belongs to the family Acanthaceae, native to India and Sri Lanka. It is one among the prioritized 32 medicinal plants by the NMPB. It is also known by names deshikariyatu (Gujarati), kalmegha (Sanskrit), meaning dark cloud green chirayta (English), kirayat (Hindi), kalmegh (Bengali), chirota (Assamese), bhuinimba (Oriya) and nilavembu in Tamil. Since time immemorial, village and ethnic communities in India have been using this herb mainly for treating diseases like H_1N_1, swine flu, dengue fever, liver diseases, diabetes, snake bite, common cold and bronchitis and a variety of ailments" (Shalini and Narayanan, 2015).

It is estimated that around 7000 different kinds of medicinal plants are used in documented and traditional medical systems such as Ayurveda, Unani, Siddha, and homoeopathy (AYUSH System of Medicine). In India, the AYUSH system contains codified

versions of some 8,000 herbal treatments. For their primary healthcare, more than 70% of Indians rely on the traditional medical system, which includes herbal treatment.Alkaloids, steroids, tannins, phenolic compounds, flavonoids, resins, fatty acids, gums, and other secondary metabolites are often combined to produce the important therapeutic effects of plant materials.

Kamegh is one of the most significant medicinal plants that is frequently used in Indian traditional medicine to treat a variety of illnesses. This herb is said to have astringent, anodyne, tonic, and alexipharmic qualities. Additionally, Kalmegh has shown its effectiveness in managing HIV/AIDS (Shalini and Narayanan, 2015). The five plant parts (stem, leaf, flower, seed, and root) collectively known as "Panchang" are utilised in the numerous homoeopathic and Ayurvedic medication compositions used in India. It was suggested in the 175 BC "Charak Samhita" for the treatment of jaundice in combination with other plants in a multiplant concoction. Of the 32 Indian medicinal plants that are prioritised, Kalmegh is ranked 17th, with an annual growth rate of 3.1% and a demand of 2,197.3 tonnes (Kumar et al., 2023). India is home to twenty-eight different species. Based on an annual growth rate of 3.1% and a demand of 2,197.3 tonnes, Kalmegh ranks 17th out of 32 medicinal plants that India has prioritised. India is home to 28 different species, of which 10 are medicinal (*Andrographis paniculata* being the most well-known) and 18 are indigenous. Amya *et al.* (2011) suggest that *A. paniculata* leaf crude extract can be utilised as a biopesticide to manage *H. armigera*.

Andrographis paniculata can reach a height of 30 to 110 cm and grown in damp, shaded areas. The thin stem has wings at the corners and longitudinal furrows along its square cross section. It is a dark green colour. Hairless blades up to 8 cm long and 2.5 cm wide adorn the lance-shaped leaves. It is a self-pollinating crop. A capsule, a few millimeters broad and around two centimeters long, the fruit is yellow-brown. Kalmegh is annual, Diploid (2n=50), self-pollinating, extensively trafficked, therapeutic herb. According to Boopathi (2000), the genus Andrographis comprises approximately 40 species, with *Andrographis paniculata*, also known as kalmegh, being the most widely used medicinal herb.It's originated from southern regions of India and Sri Lanka, and it is widely distributed throughout the country's tropical and subtropical areas (Le *et al*., 2007).

Andrographolide is present in the plant. Kalmegh leaves are rich in active ingredients such as andrographolide, homo-andrographolide, andrographesterol, and andrographone. Akowuah*et al.* (2006) report that the plant's leaves have a variety of diterpene lactone derivatives, the two most significant of which are andrographolide, a bitter element, and neoandrographolide, a non-bitter constituent.

Andrographolide content ranges from 0.81 to 2.78% on average. The andrographolide content, which ranges from 0.72 to 2.99%, was also found to be widely distributed (Raina *et al*., 2013). The concentration of these active components varies among plant parts and according to the species' geographic range. As secondary metabolites, andrographolide is frequently affected by seasonal variations, climatic conditions, and the distribution of the compound throughout the plant.

The use of organics to increase production is encouraged, because the ongoing use of chemical fertilizers has caused heavy nutrient withdrawal from the soil (Prasad and Singh, 1980) and Serhii *et al*., 2021, which has resulted in nutrient imbalance, micronutrient deficiencies, and a decrease in crop yield. The main source of organic nutrients is FYM, and vermicompost may provide plants with nutrients gradually but steadily throughout their growth cycle. They have the potential to be employed as fertilizers for the soil and plant growth media ((Basak *et al*., 2013). Vermicompost is a kind of biological fertilizer that is produced when organic matter in the digestive tracts of some earthworm species passes continuously and slowly. The materials are impregnated with vitamins, enzymes, and the gastrointestinal mucosa as they move through the earthworm's body before defecating. Soil quality and fertility are enhanced by using it as an enriched and very beneficial organic fertilizer (Haribhushan*et al.*, 2013).The application of vermicompost and castor cake enhanced Kamegh's herbage and bioactive chemical compounds (Basak *et al*., 2020).The best method for supplementing major and minor elements is foliar organic fertilization, which includes using fish amino acid and panchakavya as liquid plant nourishment. The Vedas and Vrkshayurveda(where Vrksha means plant and Ayurveda mean healing system) contain references to Panchakavya. Texts on Vrkshayurvedasystematize farmers' field-level practices within a theoretical framework and define plant growth stimulants. Panchakavya is one such stimulant that improves crop plants' biological efficiency and the quality of fruits, vegetables, and flowers. They raise the quality and yield of herbage, which boosts farm profitability. Additionally, it enhances the intake and effective use of other crucial inputs, most notably

fertilizers. In addition to helping farmers maximize their investments, this also lessens their negative effects on the environment. In this situation, applying organic manures to the soil along with foliar organics spraying becomes more important. In order to encourage N-fixation and P-mobilization, this entails using foliar organics in addition to organic manures. When organic fertilizers are applied consistently and in sufficient amounts, soil organic carbon, soil water retention, and physical soil qualities improve. This reduces Pollution risks and fertilizer costs.

Materials and Methods

The present investigation was carried out the Department of Horticulture, Faculty of Agriculture, Annamalai University, Annamalai Nagar, Tamil Nadu during the year of 2019 to 2020.The experimental site is located in the southern region of India at latitude 11°24' N and longitude 74°44' E, at an elevation of + 5.79 m above mean sea level. During the experiment, the temperature and relative humidity ranged from 28.5 to 38.5ºC and 78.0 to 96.0%, respectively. The experimental farm's soil is categorized as Typic Haplusterts (clay), with characteristics such as neutral reaction (pH 7.4,7.5), organic carbon content 4.6 and 5.8 g kg^{-1}, CEC of 20.7 and 21.4 c mol (P+) kg^{-1}, low available N (227 and 230 kg ha^{-1}), medium available P (1.9 and 21.3 kg ha^{-1}), and high available K (281 and 276 kg ha^{-1}).The experiment was laid out in a Randomized Block Design with three replication and twelve treatments comprising of different combination of (i) basal organics *viz.*, Farm Yard Manure, Vermicompost and Pressmud (ii) foliar spray of organics *viz.*, panchagavya and fish amino acid and untreated control. The treatments details are FYM@ 15 t ha^{-1} (T_1),Vermicompost @ 5 t ha^{-1}(T_2), Pressmud @ 15 t ha^{-1} (T_3), Panchakavya @ 3% (T_4) Fish amino acid (FAA) @ 3 % (T_5), FYM @ 15 t ha^{-1} + panchakavya @ 3 % (T_6),) FYM @ 15 t ha^{-1} + fish amino acid @ 3 % (T_7), Vermicompost @ 5 t ha^{-1}+ panchakavya @ 3 % (T_8), Vermicompost @ 5 t ha^{-1}+fish amino acid@3 % (T_9), Pressmud@ 15 t ha^{-1} + panchakavya @ 3 % (T_{10}) Pressmud@ 15 t ha^{-1} + fish amino acid @ 3 % (T_{11}) and Control (T_{12}). The foliar organics *viz.*, fish amino acid and panchakavya were given as per the treatments in individual plots and foliar spray was done at 15th, 45thand 75th DAP. At the time of spray, required quantity of foliar organics *viz.*, fish amino acid and panchakavya @ 3% was prepared as per the treatment schedule. Spraying was done with hollow cone pore size nozzle.

Preparation of panchakavya

Ingredients for making panchakavya are: cow dung slurry (4 kg), fresh cow dung (1 kg), cow urine (3 L), cow milk (2 L), cow curd (2 L), sugarcane juice (3 L), ghee (1 kg), and bananas (12 nos.). All the above-mentioned items were added to a wide-mouthed mud pot, concrete tank, or plastic can in the order specified above. The container was kept open in the shade. The contents were stirred twice a day, both in the morning and evening. The panchakavya stock solution was ready after 7 days. Care was taken not to mix with buffalo products.

Composition of panchakavya

Contents	Concentration	Contents	Concentration
Total nitrogen (mg kg^{-1})	302	pH	5.6
Total phosphorus (mg kg^{-1})	218	Zn (mg kg^{-1})	0.26
Total potassium (mg kg^{-1})	355	Mn (mg kg^{-1})	0.23
Organic carbon (%)	0.80	Cu (mg kg^{-1})	0.20

Preparation of Fish amino acid

Fish trash was gathered from local fish markets and finely chopped. Jaggery was ground into a powder. The container was correctly closed after a layer of chopped fish waste and powdered jaggery was added alternately. The mixture of fish excrement broke down and became a brown liquid after 60 days. This solution was kept in a ready-to-use state after being filtered through a wire mesh and smelling like palm fruit.

Composition of fish amino acid

Parameters	Values	Parameters	Values
Total nitrogen (%)	1.96	Total potassium (%)	0.19
Total phosphorus (%)	1.04	Organic carbon (%)	34

Organic manures like farmyard manure and vermicompost was obtained from departmental unit of horticulture. The cattle dung and urine, along with litter and left-over fodder fed to the cattle, are used for the preparation of FYM. Average rage of well decomposed farmyard manure contains N (0.5%), P_2O_5 (0.2%) andK_2O (0.5). Vermicompost nutrient content nitrogen (1.2% to 2.5%), phosphorus (0.9% to 1.7%) and potassium (1.5% to 2.5%).Pressmud were collected from M.R.Krishnamoorthy Sugar Mill, Sethiyathoppu,

Cuddalore District. These organic manures were given as per the treatments in individual plots and incorporated before planting. Seedlings that were 45 days old were transplanted to the main field that had been prepared, with a spacing of 30 x 15 cm.Light watering can be applied as needed at regular intervals for up to 8 to 10 days after seedling transplantation in order to promote early seedling establishment. After that, the field is irrigated every 20 to 25 days, depending on what the soil needs.

The observations on growth characters were recorded for plant height, number of branches, and number of leaves per plant. Physioilogical parameters *viz.*, leaf area plant^{-1}, total dry matter production plant^{-1}. Yield parameters *viz.*, fresh herbage yield plant^{-1} and dry herbage yield plant^{-1} andN, P and K uptake**.** The data recorded were subjected to statistical analysis by adopting the standard procedure of Panse and Sukhatme (1985). The critical differences were worked out at 5 per cent probability significance. The analysis was carried out using the personal computer based IRRISTAT package.

Results and discussion

Plant height

Significant differences in the plant height (Table 1) were observed among the various treatments at all the stages of growth. The highest plant height (69.80 cm) was recorded in T_9 (Vermicompost @ 5 t ha^{-1}+fish amino acid @ 3 %) followed by T_7 (FYM @ 15 t ha^{-1}+ fish amino acid @ 3 %) which registered the values of 63.13 cm. The plant height was least in control (T_{12}) (36.12 cm). Thus, the result of maximum plant height was due to foliar application of Panchakavya @ 3 % and Fish amino acid @ 3 % which helps in the translocation of N present in the FYM and also from soil. This result is in agreement with the findings of Rajamani *et al.*, 2007, Mara *et al*., 2024, Rabey *at et*., 2023 and Carlo Lynngdoh*et al.,* 2017 in *Andrographis paniculata* and cowpea respectively. In general, Organic manures reduce the need for chemical fertilizers, to improve the soil fertility and soil health (Myint *et al.,* 2010). Another possible reason for higher growth characters might be due to the growth enzymes present in panchakavya, which favoured rapid cell division and multiplication. Also increased supply of numerous plant nutrients from farmyard manure to the plants, which might have promoted the growth of lateral shoots. The result of the present investigation was in accordance with the reports of Prabhu *et al.* (2010) who reported that increased plant growth, as evidenced by increase in height, number of branches, number of leaves plant^{-1} is due to auxins, which is present in panchakavya, attributed to the activation of cell division

and cell elongation in the axillary buds, which had a promoting effect in increased number of branches.

Number of branches and number of leaves per plant

The maximum number of branches (28.10) and number of leaves (140.87) was observed in vermicompost @ 5 t ha^{-1}+ fish amino acid @ 3 % (T_9)(Table 1). The minimum number of branches (15.05) and number of leaves (113.62) was recorded in treatment T_{12} (Control).The improvement in growth characters is due to the proper application of FYM, vermicompost and pressmud in soil, which supplies the available nutrients to the plant and creates a favourable soil environment, which ultimately increases the nutrient and water holding capacity of soil for a longer period, which results in better growth attributes. The combined application of all these characters resulted in the maximum growth in Kalmegh. Number of leaves in a plant and branch has an immersive role in the photosynthetic efficiency of the plant to produce more biomass. Vermicompost, in particular, is an incredibly effective organic input for plant growth that speeds up the growth of many different plant species (Kumaresan *at al*., 2023).

Physiological parameters

Leaf area $plant^{-1}$

The data on leaf area per plant at different growth stages are presented in Table 1. Treatment T_9 (Vermicompost @ 5 t ha^{-1}+fish amino acid @ 3 per cent) significantly registered the maximum leaf area of 456.57 cm^2 $plant^{-1}$. This was followed by T_7 (FYM @ 15 t ha^{-1} + fish amino acid @ 3 per cent), which recorded 425.60 cm^2. The treatment T_{12} (Control) registered the minimum leaf area of 156.44 cm^2. This may be due to nutrients released from farmyard manure, which contributed to the growth parameter by increasing the leaf area and leaf area index. Similar findings were reported by Sadashiv Nadukeri*et al.* (2007) is that application of vermicompost leads to improvement in highest plant height, number of branches $plant^{-1}$ and leaf area index recorded in Coleus (*Coleus forskohlii*). Leaf expansion observed in the present experiment due to application of vermicompost and fish amino acids as foliar spray (T_9) might be due to the presence of GA_3, IAA and Cytokinin as a source in vermicompost, as reported by Mukesh Kumar *et al.*(2018).

Total dry matter production (TDMP) $plant^{-1}$

The highest TDMP of 13.24 g $plant^{-1}$ was recorded by the treatment T_9 (vermicompost @ 5 t ha^{-1} + fish amino acid @ 3 per cent) followed by T_7 (FYM @ 15 t ha^{-1} + fish amino

acid @ 3 per cent)which recorded 12.13 g plant^{-1}. (T_{12}) Control recorded the lowest TDMP of 4.13 g plant^{-1}(Table 1). This may be due to the fact that the basal application of FYM, Vermicompost and pressmud at the initial phase of crop growth contributes to the nutrient supply and in turn uptake was promoted by foliar supplementation of nutrients and hormones through panchagavya and fish amino acid during the later growth phase. To increase the photosynthetic rate, this could have led to higher uptake of nutrients and accumulation of dry biomass during the life cycle of the crop. A similar compatibility was noticed by Harisha *et al.* (2010) in garden cress and by Hemalatha (2010) in Kalmegh.

Yield attributes

The highest fresh herbage yield (Table 1) of 42.74 g plant^{-1} and dry herbage yield of 14.24 g plant^{-1}(Fig.1), was recorded from the treatment T_9 (Vermicompost @ 5 t ha^{-1}+fish amino acid @ 3 per cent) and lowest fresh herbage yield of 18.54 g plant^{-1}, dry herbage yield of 6.18 g plant$^{-1,}$ fresh leaf yield of 21.43 g plant^{-1}anddry leaf yield of 5.83 g plant^{-1}

Yield attributes like fresh herbage yield plant^{-1} and ha^{-1} and dry herbage yield plant^{-1} played a vital role in increasing the productivity of the Kalmegh crop. The results are in accordance with the findings reported by Mumtaz Husain and Manoj Kumar (2014),Chand *et al.*, (2011), Dakhane and Nandkar (2012), Kanjilal*et al.*, (2002), Makwana *et al.*, (2010), Ramesh *et al.*, (2011) and Sanjutha *et al.*, (2008), Singh *et al.*, (2011) also studied the yield effect and found a better result in organic fertilizers.

Nutrient uptake

N, P and K content

There were significant differences due to different organic manures and foliar application of organic treatments on plant nutrient uptake(Table 1). The maximum N, P and K content was exhibited by T_9 (Vermicompost @ 5 t ha^{-1}+fish amino acid @ 3 % (38.97 Kg ha^{-1}), (6.87 Kg ha^{-1}) and (84.23 kg ha^{-1}) and minimum was envisaged in T_{12} control (21.53 Kg ha^{-1}), (1.23 Kg ha^{-1}) and (20.38 Kg ha^{-1}). The vermicompost, FYM and fish amino acid application increased the nutrient status of the soil and increased the nutrient availability throughout the growth stages and resulted in similar increased uptake of nutrients in the application of vermicompost and FYM along with foliar spray of fish amino acid and panchakavya supplied the plot. This is due to the compatible effect of the fish amino acid foliar application with vermicompost.Well-decomposed vermicompost and FYM have a narrow C:N ratio, they are rich sources of nitrogen. The cumulative effect of panchakavya,

which provides nutrients gradually and steadily during the crop growth period, also enhances the availability of nutrients. This finding is consistent with the findings of Grill *et al.* (1999), who found that plants treated with FYM had greater N content. One of the key ingredients of Panchakavya, cow's urine is high in nitrogen and would have been easily obtainable by the plants, which in turn affects the amount of nitrogen in the leaves. Farmyard manure that has decomposed well often has 0.5 percent N, 0.2 percent P_2O_5, and 0.5 percent K_2O. Another crucial element is phosphorus, which is a structural component of co-enzymes, phosphorlipids, phosphorproteins, and nucleic acids that are involved in the majority of metabolic pathways (Tate, 1984). The synthesis of phenolic and aliphatic acids during the breakdown of vermicompost by the beneficial microorganism may be the cause of the increased P content in the leaves, as impacted by the application of vermicompost 5 t ha^{-1} + Fish amino acid at 3% as foliar spray. Significant amounts of P were soluble from their insoluble state, thanks to these acids.

Applying fish amino acid at 3% foliar and vermicompost at 5 t ha^{-1} considerably raised the leaf K content. The use of vermicompost may have enhanced the potash K availability in the soil, which could be the cause. The increased output of herbage may have resulted from the elevated physiological parameters caused by the bioactive chemicals found in fish amino acid and vermicompost. In Kalmegh, Hemalatha *et al.* (2010) and Sanjutha *et al.* (2010) have noted similar effects.

Conclusion

The present experiment is concluded that the Vermicompost (5 t ha^{-1} +fish amino acid @ 3% foliar spray) can be considered as the best organic manure combination to obtain maximum yield of good quality herbage from Kalmegh.

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Fig. 1. Effect of organic manures and foliar application on dry herbage yield (g/plant) of kalmegh

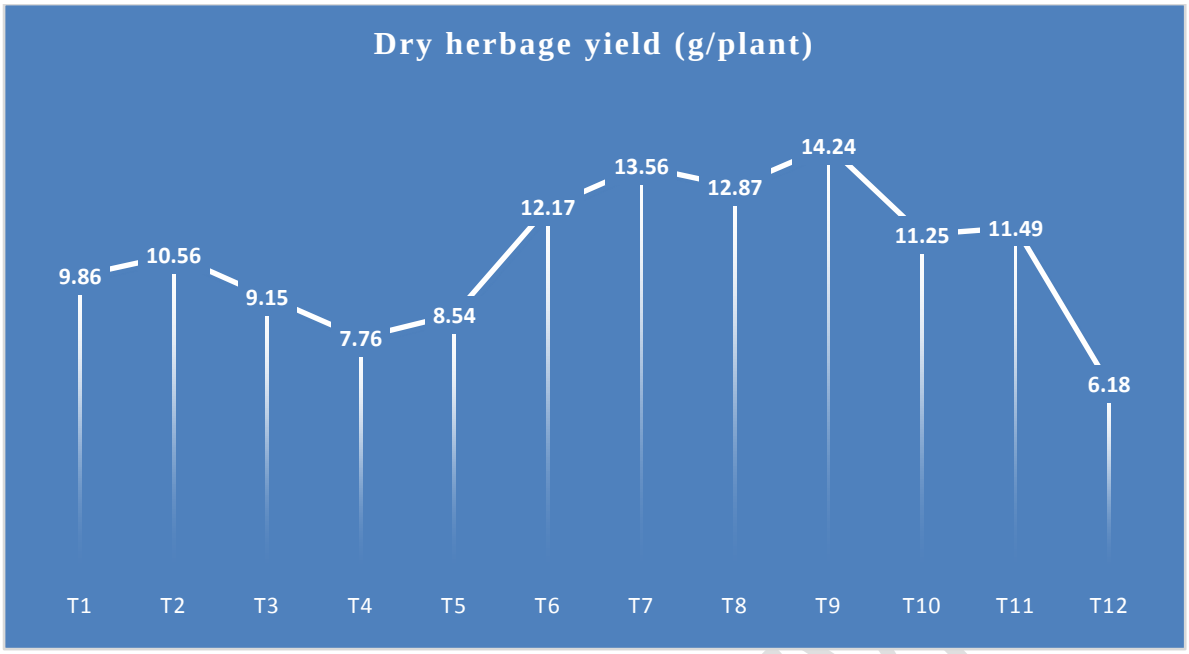

Table 1. Effect of organic manures and foliar application on growth,yieldcharactersand

Nutrient uptake of kalmegh

Treatments	Plant height (cm)	Number of branches plant^{-1}	Number of leaves	Leaf area plant^{-1}	Total dry matter production (TDMP) (g/plant)	Fresh herbage yield (g/plant)	Nutrient uptake (kg ha^{-1})		
							N	P	K
T_1	45.88	19.16	123.92	3.87	7.50	27.08	38.97	3.58	45.85
T_2	48.78	20.30	127.73	4.27	8.78	29.34	43.93	4.06	52.33
T_3	43.10	17.96	120.64	3.46	6.33	24.81	34.26	3.08	39.23
T_4	39.02	16.16	116.82	2.67	3.99	20.93	26.58	2.16	27.52
T_5	41.87	17.62	119.23	3.12	5.41	23.21	31.14	2.67	34.25
T_6	57.24	24.01	134.01	5.39	12.21	35.91	58.70	5.40	67.98
T_7	63.13	26.43	138.42	6.35	14.66	40.48	69.24	6.38	78.80
T_8	60.08	25.13	136.12	5.90	13.44	38.18	63.88	5.90	73.40
T_9	69.80	28.10	140.87	6.78	15.86	42.74	74.36	6.87	84.23
T_{10}	51.62	22.24	130.25	4.72	9.99	31.85	49.34	4.57	58.54
T_{11}	54.25	22.83	132.00	4.97	10.99	33.65	53.34	4.92	62.54
T_{12}	36.12	15.05	113.62	2.09	2.34	18.54	21.53	1.23	20.38
S. Ed	**1.35**	**0.57**	**1.12**	**0.21**	**0.54**	**1.16**	**2.20**	**0.23**	**2.66**
CD (P = 0.05)	**2.75**	**1.13**	**2.26**	**0.39**	**1.12**	**2.24**	**4.4**	**0.47**	**5.32**

T_1 –FYM @ 15 t ha^{-1}
T_2 – Vermicompost @ 5 t ha^{-1}
T_3 – Pressmud @ 15 t ha^{-1}
T_4- Panchakavya @ 3%
T_5 - Fish amino acid (FAA) @ 3 %
T_6 – FYM @ 15 t ha^{-1} + panchakavya @ 3 %
T_7 – FYM @ 15 t ha^{-1}+ fish amino acid @ 3 %
T_8 – Vermicompost @ 5 t ha^{-1}+ panchakavya @ 3 %
T_9 – Vermicompost @ 5 t ha^{-1}+ fish amino acid @ 3 %
T_{10} – Pressmud @ 15 t ha^{-1} + panchakavya @ 3 %
T_{11} – Pressmud @ 15 t ha^{-1}+ fish amino acid @ 3 %
T_{12} - Control