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Effect of Different Organic Manures along with Microbial Consortia on Growth and Yield of Kalmegh (*Andrographis paniculata* Nees.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Kalmegh has wide range of medicinal and pharmacological applications. The active ingredient andrographolide is important bioprotectant. Organically grown medicinal plants fetch premium price in the market. Hence the need to explore different manures along with microbial consortia to improve its yield is essential. The experiment was laid out in RCBD with thirteen treatments. Different organic manures and combinations with neem cake were taken as treatments with three

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replications. Significantly higher plant height was observed in treatment - 100% RDF through vermicompost. Maximum plant spread was recorded in the treatment - 50% RDF through FYM + 50% RDF through neem cake + microbial consortia. Application of sheep manure + neem cake resulted in higher number of branches plant^{-1}, higher number of leaves plant^{-1}, highest fresh weight, highest dry weight, highest root to shoot ratio, highest fresh herbage yield and highest B:C ratio. So, sheep manure + neem cake was found best compared to other manures and combinations.

Keywords: Kalmegh; medicinal and pharmacological applications; medicinal plants; microbial consortia.

1. INTRODUCTION

Kalmegh *(Andrographis paniculata)* belong to the family 'Acanthaceae' which is also known as Maha tita and Kalpanath.

The plant is also known as the 'king of bitters' [1,2] because it is extremely bitter in taste in every part of plant body. On the basis of literature survey, it has been observed that the aerial parts (leaves and stems) of the plants are most commonly used to extract the active phytochemicals, however the whole plant or roots are mentioned to a limited extend [2]. *A. paniculate* has a broad spectrum of pharmacological effects and some of them are extremely beneficial such as Hepatoprotective, antimicrobial, antifungal, antioxidant, anti-inflammatory, antipyretic, anticancer and antidiarrheal effects. Nyeem et al*.,* [3].

According to Unani system of medicine it is useful in the treatment of chronic hepatitis. The roots give flavones, apeigenin-7, 4'-dio-O-methyl ether, 5-hydroxy-7, 8, 2´, 3´-tetra methoxy flavone, andrographin and panicolin and sitosterol. Leaves of Kalmegh contain homoandrographolide, andrographosterol and andrographone. Active compounds of Kalmegh sold in market by different trade names like Actizeet, Bixa botanical, Life Aveda and other products like Acene-n-pimple cream (Himalaya wellness), Liv 52 (Himalaya Drugs Company), Lerbohep (Lupin Herbal Laboratory), Sage Liverex (Sage Herbals), Purodil syrup (Aimil Pharmaceuticals). Researches conducted in the past have confirmed that *A. paniculata* if properly administrated, has a surprisingly broad range of pharmacological effects. The major source of supply of Kalmegh is Tropical forests.

India is a global leader in the production of medicinal and aromatic plants. The National Medicinal Plants Board and the Food and Agriculture Organization recommended that all the medicinal and aromatic plants to be cultivated organically. Organically grown medicinal and aromatic products are not only readily acceptable in global market but also fetch premium prices than those grown with conventional farming. (Aishwath and Tarafdar) Annually, India's medicinal plants export is worth of Rs.1250 crores. Organically grown medicinal and aromatic plants have an excellent global market and India can exploit this market to its advantage [4].

Results on application of organic manures on medicinal and aromat plants revealed that enhancement of yield and uptake of nutrients. Not only organic manures, biofertilizers (Azotobacter and Azospirillum), arbuscular mycorrhizal (AM) fungi and phosphorus solubilizing bacteria, organic mulches and crop rotations are also play an important role for the enhancement of yield and nutrients utilization.

Influence of organic nutrients on biological yield and bioactive principle of Kalmegh is well pronounced according to different literatures. Organic manures and bio-fertilizers improve soil quality and beneficial soil microorganisms. Keeping the importance of both organic cultivation and beneficial effects of organic manure, the present investigation, study on effect of different organic manures along with microbial consortia on growth and yield of Kalmegh (*Andrographis paniculata* Nees) was carried out.

Objective of the investigation: To Study the effect of different organic manures along with microbial consortia on growth and yield of *Kalmegh.*

2. MATERIALS AND METHODS

I. **Place of study:** Sanjeevini vatika, Medicinal plants block, Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bengaluru.

II. **Seed collection:** Kalmegh seeds of variety CIM- Megha was collected from CSIR-Central Institute of Medicinal and Aromatic Plants, Bengaluru.

III. **Seedlings:** The seedlings were raised in the nursery and 30 days old seedlings were transplanted in the experimental plots.
IV. **Materials:** Measuring scale, electronic weighing scale, hot air oven
V. **Season:** *kharif* season during the year 2021-2022
VI. **Location:** The experimental site is situated at 12° 58" North latitude and 77° 55" East longitude with an elevation of about 930 meters above mean sea level.
VII. **Temperature, Rainfall & RH:** The mean of maximum and minimum temperature recorded during the period of experiment was 27.7° C and 18.5 ° C, respectively. The average of total rainfall received from June to September was 156 mm. The mean maximum and minimum Relative Humidity (RH) of the location was 89.5 per cent and 58.7 per cent, respectively.

Organic manures like Farm Yard Manure (FYM), Poultry manure, Sheep manure, Vermicompost and Neem cake were procured from Zonal Agricultural Research station (ZARS), University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bengaluru. Microbial consortia was purchased from bio-fertilizers production laboratory, Department of Microbiology, University of Agricultural Sciences, Gandhi Krishi Vigyana Kendra, Bengaluru. The above-mentioned microbial consortia consisted the mixture of phosphate solubilising bacteria, trichoderma and pseudomonas.

The experiment was laid-out in Randomized Complete Block Design (RCBD) replicated thrice with thirteen treatments in open field condition. The treatments consisted of combination of different organic manures with and without microbial consortia.

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

The data pertaining to effect of different organic manures with and without microbial consortia on plant height of Kalmegh is presented in Table 1 and depicted in Fig. 1.

Among the treatments, T_4 (100 % RDF through Poultry manure) has recorded significantly highest plant height (14.53 cm) at 30 Days After Transplanting (DAT) which was found to be on par with treatment T_2, T_4, T_9, T_{12} and T_{13} (12.47 cm,14.40 cm,13.20 cm, 12.67 cm and 12.67 cm respectively) at 30 DAT.

At 60 DAT, significantly highest plant height of 34.30 cm was recorded in the treatment supplied with 100 % RDF through poultry manure which was found to be on par with treatment T12 (32.37 cm) and the least plant height (10.10 cm & 24.30 cm at 30 & 60 DAT respectively) was observed in the treatment T1 (control).

The result with respect to plant height at 90 Days After Transplanting (DAT) was found to be significant. Highest plant height (49.4cm) was recorded in the treatment T_5 (100% RDF through vermicompost) and least plant height was observed in the treatment T_1 (Control).

The significant increase in plant height was noticed with the application of poultry manure. This might be due to the fact that it is higher in nitrogen content and has instant nutrient releasing property along with rich organic matter content. This might have resulted in recording the higher values of plant height. Similarly, vermicompost was found to be best due to presence of plant growth hormones in it and is rich in humus than other organic manure but slower in decomposition rate when compared poultry manure. Similar results were reported by Kumar and Topal [5] and Detpiratmongkol et al. [2] in Kalmegh and Thanuja et al. [6] in Ajwain; Ronya et al. [7] in Turmeric; Smitha et al. [8] in sacred basil.

3.1.2 Number of branches per plant

The data pertaining to effect of different organic manures on number of branches in Kalmegh is presented in Table 1.

The data recorded on number of branches per plant was found to be significant. The treatment provided with 100% RDF through poultry manure has recorded significantly highest number of branches (11.60) at 60 DAT, which was found to be on par with treatment T_7 (11.13) while the least (5.20) was recorded in the treatment T_1 (Control).

The data with respect to number of branches at 90 DAT was found to be significant. Highest number of branches (14) was recorded in the treatment T_7 (50% RDF through Sheep manure + 50% RDF through neem cake) which was followed by the treatment T_4 (13.67) and least number (10.0) of branches were observed in the treatment T_1 (Control).

List 1. Treatment details

T_1	Control (No manure)
T_2	100% RDF through FYM
T_3	100% RDF through Sheep manure
T_4	100 % RDF through Poultry manure
T_5	100% RDF through Vermicompost
T_6	50% RDF through FYM + 50% RDF through Neem cake
T_7	50% RDF through Sheep manure + 50% RDF through Neem cake
T_8	50% RDF through Poultry manure + 50% RDF through neem cake
T_9	50% RDF through Vermicompost + 50% RDF through Neem cake
T_{10}	50% RDF through FYM + 50% RDF through Neem cake 50% + Microbial consortium
T_{11}	50% RDF through Sheep manure + 50% RDF through Neem cake + Microbial consortium
T_{12}	50% RDF through Poultry manure + 50% RDF through Neem cake + Microbial consortium
T_{13}	50% RDF through Vermicompost + 50% RDF through Neem cake + Microbial consortium

RDF: Recommended Dosage of Fertilizer; Organic manures were calculated on N equivalent basis (RDF: 75: 75: 50 N, P and K kg/ha) and the spacing followed was 30 cm X 15 cm with the individual plot size of 2.7m X 2.1m

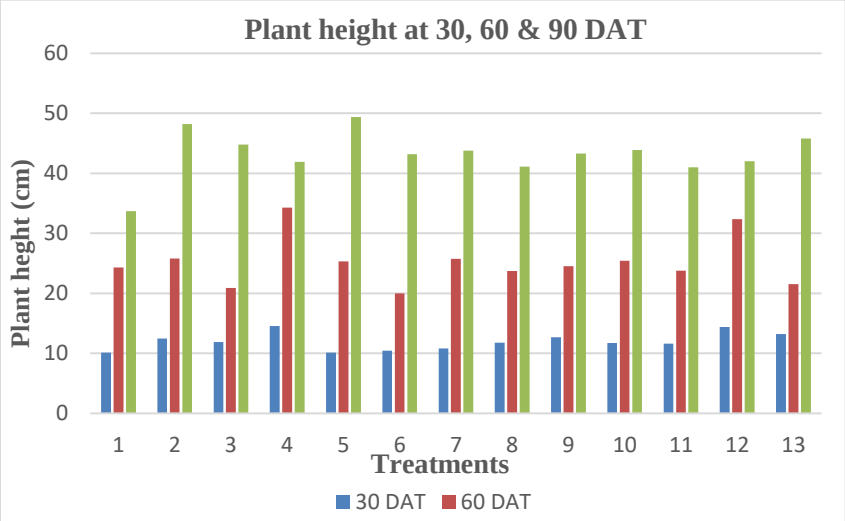

Fig. 1. Effect of different organic manures along with microbial consortia on plant height in Kalmegh

The significant increase in number or branches with the application of poultry manure and sheep manure in combination with neem cake might be due to the fact that poultry manure contains thirteen essential plant nutrients that are used by the plants and contains N in the form of uric acid which is instantly available for plant uptake. Similarly, sheep manure is high in both phosphorous, potassium and essential elements for better plant growth whereas neem cake enhances its efficiency and release nutrients very slowly making it available throughout the crop growth period. The results are in conformity with the work carried out by Shahjahan et al. (2013) in Kalmegh, Smitha et al. [8] in sacred basil and Singh et al. (2012) in *Coleus forskohlii.*

3.1.3 Plant spread (cm^2)

The perusal of data presented in Table 1 indicate that different organic manures along with and without microbial consortia had significant influence on plant spread.

Among the treatments, T_4 (100 % RDF through poultry manure) and T_{12} (50% RDF through poultry manure + 50% RDF through neem cake + microbial consortium) has recorded significantly highest plant spread (95.37 cm^2 and 353.47 cm^2 at 30 and 60 DAT respectively) which was found to be on par with treatments T_2, T_3, T_7, T_8, T_9, T_{12} and T_4 (66.97 cm^2, 59.93 cm^2, 62.73 cm^2, 54.25 cm^2, 57.92 cm^2, 59.23 cm^2, 81.65 cm^2 and 346.68 cm^2 at 30 and 60 DAT respectively) and least plant spread (95 cm^2 & 775.2 cm^2) was observed in the treatment T_1 (control).

The result with respect to plant spread at 90 DAT was found to be significant. Highest plant spread (2209.6 cm^2) was recorded in the treatment T_{10} (50% RDF through FYM+ 50% RDF through Neem cake + Microbial consortium) which was

on par with treatment T_4 (1475.8 cm^2) and least plant spread (775.2 cm^2) was observed in the treatment T_1 (Control).

The significant difference in plant spread was noticed with the application FYM along with neem cake because FYM with combination of neem cake releases nutrients at a slower rate. So, at later stage plants treated with the combination of FYM, neem cake and microbial consortia might have shown better growth. Similar findings were studied by Tiwari et al. [9] in Kalmegh, Smitha et al [8] recorded maximum plant spread in sacred basil where organic manures and biofertilizers used in combination as compared to application of biofertilizer or organic manure alone. Singh et al. (2012) worked on *Coleus forskohlii* plants treated with Arbuscular Mychorriza, Neem cake and *Pseudomonas florescence* showed significantly increased plant spread.

3.2 Yield Parameters

3.2.1 Fresh weight of plant (g)

The fresh weight of plant influenced by different organic manures along with microbial consortia in Kalmegh is shown in the Table 2 and Fig. 2.

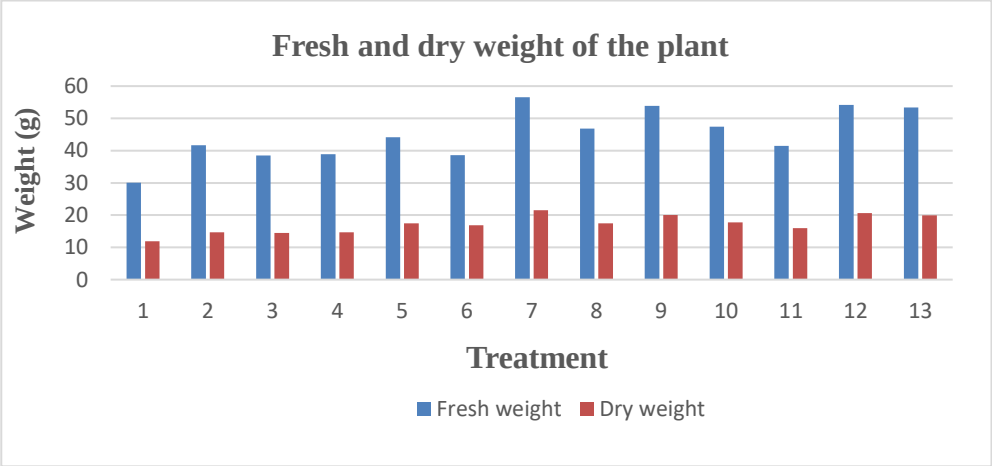

Fig. 2. Effect of different organic manures along with microbial consortia on fresh and dry weight of the plant in kalmegh

Table 1. Influence of different organic manures along with microbial consortia on yield parameters of Kalmegh

Treatment	Plant Height (cm)	Plant Spread (cm^2)	Number of Branches / Plant
T_1	33.7	775.2	10
T_2	48.2	1160.2	12.4
T_3	44.8	1086.2	12.4
T_4	41.9	1475.8	13.67
T_5	49.4	1955.4	13.6
T_6	43.2	840.2	11.6
T_7	43.8	1108.8	14
T_8	41.1	1046.6	10.8
T_9	43.3	1372.4	13.6
T_{10}	43.9	2209.6	10.8
T_{11}	41.0	1137.2	11.33
T_{12}	42.0	847.0	13.5
T_{13}	45.8	804.2	13.1
'F' test	*	*	*
S Em±	**0.27**	**31.7**	**0.09**
CD (P=0.05)	**0.80**	**92.8**	**0.28**

**Significant at 5% level*

Table 2. Influence of different organic manures along with microbial consortia on yield parameters of Kalmegh

Treatment	Fresh Weight of Plant (g)	Dry Weight of Plant (g)	Herbage Yield / Plot (kg)	Herbage Yield / Hactare (q)
T_1	30.01	11.9	3.36	59.3
T_2	41.7	14.72	4.24	75.0
T_3	38.52	14.52	4.34	76.0
T_4	38.9	14.64	4.39	77.0
T_5	44.11	17.5	5.05	89.0
T_6	38.62	16.9	4.8	85.0
T_7	56.60	21.49	6.6	116.0
T_8	46.85	17.5	5.3	95.0
T_9	53.86	20.06	6.28	110.0
T_{10}	47.47	17.75	5.47	96.0
T_{11}	41.50	15.95	4.85	85.0
T_{12}	54.20	20.58	6.46	113.0
T_{13}	53.4	19.91	6.22	109.8
'F' test	*	*	*	*
S Em±	**0.56**	**0.20**	**0.07**	**1.25**
CD (P=0.05)	1.65	**0.59**	**0.20**	**3.6**

Different organic manures along with microbial consortia influenced significantly on fresh weight of plant after 90 DAT (at harvest). The highest fresh weight of 56.60g was recorded in plant provided with 50% RDF through Sheep manure + 50% RDF through Neem cake followed by 54.20 g in plants provided with 50% RDF through Poultry manure + 50% RDF through Neem cake + Microbial consortia and 53.86 g in treatment with 50% RDF through FYM + 50% RDF through Neem cake + Microbial consortia. Kalmegh plant grown without any organic manure or combination of organic manure recorded lowest fresh weight (30.01 g). The data is in conformity with the results of Saeidnejad and Rezvani [10] in Cumin where highest yield was noticed in plants treated with sheep manure, compost, vermicompost and cow dung manure.

3.2.2 Dry weight of plant (g)

Effect of different organic manures along with microbial consortia on dry weight of Kalmegh is presented in Table 2 and depicted in Fig. 2.

Different organic manures along with microbial consortia influenced significantly on dry weight of plant. The highest dry weight of 21.49 g was recorded in plant supplied with 50% RDF through Sheep manure + 50% RDF through Neem cake followed by 20.58 g in plants provided with 50% RDF through Poultry manure + 50% RDF through Neem cake + Microbial consortia) and 20.06 g in the treatment with 50% RDF through FYM + 50% RDF through Neem cake + Microbial consortia [11,12]. Control treatment plants recorded least dry weight of 11.9 g. The results are in line with the experiments conducted by Saeidnejad and Rezvani (2010) in Cumin.

3.2.3 Herbage yield per plot (kg) and per hectare (q)

Different organic manures along with microbial consortia influenced significantly fresh herbage yield at harvest and is presented in Table 2.

The results indicated that herbage yield per plot and per hectare was significant. The highest fresh herbage yield of 6.60 kg/ plot and 116 q/ ha was recorded in treatment supplied with 50% RDF through Sheep manure + 50% RDF through Neem cake which was found to be on par with treatment supplied with 50% RDF through Poultry manure + 50% RDF through Neem cake + Microbial consortia (6.46 kg/ plot and 113 q/ ha). The least values for fresh herbage was observed in control (3.36 Kg/ plot and 59.3 q/ ha) [13-15].

This significant difference due to the application of sheep manure along with neem cake and poultry manure in combination with neem cake and microbial consortia might be due to the fact that the sheep manure enhances plant growth hormones, soil fertility and facilitate in availability of plant nutrients throughout the crop growth period whereas in poultry manure + neem cake + microbial consortia combination, poultry manure amends soil, neem cake facilitates plant nutrient

uptake and stimulative activity of microflora in the rhizosphere leading to availability of nutrients and vigorous growth and it might have resulted in recording the higher herbage yield. Similarly, Kamal and Yousuf [16] opined that among the various organic manures, Neem cake followed by poultry manure was superior to cow dung with regards to yield parameter in Turmeric. Wahab et al. [17] indicated that the combination treatment of manure, compost with biofertilizer recorded increase in yield in Fennel crop [18,19].

4. CONCLUSION

On the basis of the results obtained in the experiment, it could be concluded that plants supplied with sheep manure along with neem cake was better to get maximum growth and yield when compared to other treatment combinations and can be suggested to farmers for better growth and yield returns of Kalmegh.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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