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Effect of Organic Manures and Biofertilizers on Herb Yield and Economics of Kalmegh (*Andrographis panniculata* Wall. Ex. Nees.) var. CIM Megha

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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

Aim: To study the effect of organic manures and biofertilizers on growth, herb yield and economics of kalmegh.
Study Design: The experiment was carried out with 13 treatments in Randomized Block Design (RBD) with three replications.
Place and Duration of Study: The research trial was carried out at P.G students research block, College of Horticulture, Rajendranagar, SKLTSHU, Hyderabad during Kharif, 2021.
Results: Among the organic and biofertilizer treatments combinations the results reported that the (T_6): 75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC recorded the highest herb yield and Benefit cost ratio compared to other treatments.
Conclusion: Organic produce fetches higher price in market compared to inorganic produce, which helped in increasing the gross returns, net returns and highest B:C ratio.

Keywords: Organic manures; biofertilizers; herb yield and economics.

1. INTRODUCTION

Kalmegh (*Andrographis paniculata* Wall. Ex. Nees.) an acanthaceae member is indigenous to India and has been used in Indian systems of medicine since time immemorial. The plant is known as “Maha tita” which literally means ‘King of bitters’. In Sanskrit, it is called Bhuinimb and in telugu, Nela Vemu. It is one of the bitterest erect or recumbent, annual herbaceous plant (perennial if maintained).The major bitter constituent in kalmegh is diterpene lactone called as “andrographolide” which is 3 % in leaves and 2 % in stems. Other important constituent is a non-bitter compound, neo- andrographolide. The branches are quadrangular, leaves simple, petiolate, lanceolate with acute base and apex. Flowers are small, solitary and panicles with externally hairy, rose or purple coloured corolla, calyx-lobes glandular, pubescent, anther bearded at the base, fruits 20 mm long, linear- oblong capsules acute at both ends. Seeds are numerous (i.e. 8-12 seeds/capsule) and yellowish brown in colour [1].

Ayoola and Makinde [2] reported that organic manures like Farm yard manure, vermicompost, neem cake, poultry manure *etc.,* resulted in significant increase in soil carbon, nitrogen, pH, cation exchange capacity and exchangeable Ca, Mg and K which invariably enhance crop yield and productivity. The role of organic manures in improving soil structure, better water holding capacity and drainage which in turn help for better growth, yield and drying percentage in kalmegh.

The role of biofertilizers is perceived as growth regulators besides biological nitrogen fixation collectively leading to much higher response on various growth and yield attributing characters [3]. The extensive use of biofertilizers in crop production is the major breakthrough as pollution free low-cost input technology during recent years. Scientific evidence clearly showed that combined application of biofertilizers like nitrogen fixing, phosphate solubilizing and mobilizing microbes had positive effect on crop growth and yield. The application of combined form of N fixing, P solubilizing and Zn mobilizing, growth promoting microbes is difficult for farmers due to lack of availability in one place by Chandana et al. [4] in kalmegh.

To overcome these problems, Arka Microbial Consortium (AMC) biofertilizer has been developed and released from IIHR, Bengaluru which is recommended for media preparation, seed treatment and soil application either by fertigation or drenching. AMC contains N fixing, P and Zn solubilizing and plant growth promoting microbes as a single formulation. Organically grown products fetch higher price and also there is a great demand for organically grown plant produce in the Western countries. Hence, the present experiment has been carried out to study the effect of organic manures and biofertilizers on herb yield and economics of kalmegh.

2. MATERIALS AND METHODS

2.1 The Experimental Site

The experiment was carried out at PG Students Research Block, College of Horticulture, SKLTSHU, India, during *kharif* 2021. The experimental site is situated at a latitude of 17º.32’ north, longitude of 78º.40’ East and altitude of 542.3 m above mean sea level.

2.2 The Experimental Variants and the Experimental Design

The experiment was laid out in a complete RBD with thirteen treatments replicated thrice. The thirteen treatments *viz.,* T_1 :100 % N through FYM + AMC, T_2 : 100 % N through VC + AMC, T_3 : 100 % N through NC + AMC, T_4 : 100 % N through PM + AMC, T_5 : 75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC + AMC, T_6 : 75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC, T_7 : 75 % N through NC + 12.5 % N through PM + 12.5 % N through FYM + AMC, T_8 : 75 % N through PM + 12.5 % N through FYM + 12.5 % N through VC + AMC, T_9 : 50 % N through FYM + 25 % N through VC + 25 % N through NC + AMC, T_{10} : 50 % N through VC + 25 % N through NC + 25 % N through PM + AMC , T_{11} : 50 % N through NC + 25 % N through PM + 25 % N through FYM + AMC, T_{12} : 50 % N through PM + 25 % N through FYM + 25 % N through VC + AMC, T_{13} : Control (100 % RDF:87:75:50 kg NPK/ha) were imposed.

The experimental field was prepared well by repeated ploughing, harrowing and brought to a fine tilth. Weeds and stubbles were removed and plots were laid out along with drip laterals as per the layout plan. According to the treatments, FYM, vermicompost, neem cake and poultry manure are mixed with different combinations based on their N: P: K levels and incorporated into the soil 15 days before planting the seedlings into the main field. Soil drenching of Arka Microbial Consortium (AMC) @10 ml/L of water 20 days after transplanting near root zone for all the treatments. Whereas for Control, 100 % RDF: 87:75:50 kg NPK/ha was applied in the form of straight fertilizer.

2.3 The Determined Parameters

2.3.1 Yield parameters

The recorded data on yield parameters like fresh herb yield per plot (kg), dry herb yield per plot (kg), Fresh herb yield per hectare (q), Fresh herb yield per hectare (q), number of capsules per plant, seed yield per plot (g) were analysed.

2.3.1.1 Fresh herb yield per plot (kg)

Fresh weight of all the plants was taken from each plot as a whole and was expressed in kilograms (kg).

2.3.1.2 Dry herb yield per plot (kg)

After recording fresh weight of all the plants harvested from the net plot area, they were spread out in thin layer indoor in well ventilated room for drying. Their shade dry weight was recorded and expressed as kg/plot.

2.3.1.3 Fresh herb yield per hectare (q)

Total fresh weight was calculated by converting the yield of fresh weight per plot into hectare (q/ha).

2.3.1.4 Dry herb yield per hectare (q)

Total dry weight was calculated by converting the yield of dry weight per plot into hectare (q/ha).

2.3.1.5 Number of capsules per plant

Five plants were selected randomly in each plot and total number of capsules were counted and their average was calculated.

2.3.1.6 Seed yield per plot (g)

Ten plants were selected randomly in each plot and the seeds from the capsules were separated and then threshed, cleaned. The seed yield obtained was expressed as grams/plot.

2.3.2 Economics

The recorded data on various growth and yield components of plant were subjected to Fisher's method of "Analysis of variance" (ANOVA) as outlined by Gomez and Gomez [5]. All the data were analysed and the results are presented and discussed at a probability level of 0.05 percent.

3. RESULTS AND DISCUSSIONS

3.1 Yield Parameters

3.1.1 Fresh herb yield per plot (kg)

The data from Table 1 revealed that, significantly maximum fresh herb yield per plot (3.29 kg) was observed with T_{13} : Control (100 % RDF-87:75:50 kg NPK/ha) followed by T_6 :(75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC) (2.52 kg), T_{10} :(50 % N through VC + 25 % N through NC + 25 % N through PM + AMC) (2.46 kg), T_5 : (75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC) (2.33 kg). The minimum fresh herb yield per plot (1.78 kg) was recorded with T_4:100 % N through PM + AMC.

3.1.2 Dry herb yield per plot (kg)

The data from Table 1 revealed that, significantly maximum dry herb yield per plot (1.226 kg) was observed with T_{13} : Control (100 % RDF- 87:75:50 kg NPK/ha) followed by T_6 : (75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC) (0.981 kg), T_{10} :(50 % N through VC + 25 % N through NC + 25 % N through PM + AMC) (0.958 kg), T_5 : (75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC) (0.927 kg).The minimum dry herb yield per plot (0.665 kg) was recorded with T_4:100 % N through PM + AMC.The increase in fresh and dry herb yield was observed in T_{13}: Control (100 % RDF- 87:75:50 NPK/ha) might be attributed to the increased growth of plants in respect of height of plant and number of leaves. The healthy top growth might be responsible for the higher rate of photosynthesis, which might have accumulated carbohydrates resulting in increased number of primary and secondary branches per plant, number of leaves etc. ultimately increasing the overall herbage yield. The results are in conformity with the findings of Ahmad et al. [6] in Aloe.The higher biomass with application of organic manures and biofertilizers (AMC) might have helped the plant metabolic activity through the supply of important micronutrient such as zinc, iron, copper, manganese, etc. These are involved in biochemical synthesis of many phytohormones. Besides, organic manures and AMC have a role in nitrogen fixation and are also involved in the production of phytohormones like IAA, GA and cytokinin like substances, phosphorous solubilizing bacteria and Arbuscular mychorrizal fungi helping in solubilization and mobilization of phosphorous in soil which ultimately resulted in higher herbage yield. These results are in line with Mohanchandra [7] in makoi and Chandana et al. [4] in kalmegh.

3.1.3 Fresh herb yield per hectare (q)

At harvest significantly maximum fresh herb yield per hectare (64.21 q) was observed with T_{13} : Control (100 % RDF- 87:75:50 kg NPK/ha) followed by T_6 : (75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC) (49.45 q), T_{10}: (50 % N through VC + 25 % N through NC + 25 % N through PM + AMC) (48.89 q), T_5 : (75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC) (46.28 q). The minimum fresh herb yield per hectare (35.31 q) was recorded with T_4:100 % N through PM + AMC.

3.1.4 Dry herb yield per hectare (q)

The data from Table 1 revealed that, significantly maximum dry herb yield per hectare (24.27 q) was observed with T_{13} : Control (100 % RDF- 87:75:50 kg NPK/ha) followed by T_6 :(75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC) (19.28 q), T_{10} :(50 % N through VC + 25 % N through NC + 25 % N through PM + AMC) (18.77 q), T_5 : (75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC) (18.19 q). The minimum dry herb yield per hectare (13.07 q) was recorded with T_4:100 % N through PM + AMC. Maximum fresh and dry herbage yield per hectare (q) was recorded in T_{13}: Control (100 % RDF- 87:75:50 kg NPK/ha). Increase in per plant, per plot yields could be automatically leads to increase in per hectare yields. The results confirm with the findings of Panchabhai et al. [8] and Yadav et al. [9] in ashwagandha and Chandana et al. [4] in kalmegh.

3.1.5 Number of capsules per plant

At harvest, the data from Table 1 revealed that, significantly maximum number of capsules per plant (400.02) was observed with T_{13} : Control (100% RDF- 87:75:50 kg NPK/ha) followed by T_6 :(75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC) (334.23), T_{10} :(50 % N through VC + 25 % N through NC + 25 % N through PM + AMC) (317.13) and T_5 : (75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC) (309.54). The minimum number of capsules per plant (254.01) was recorded with T_4:100 % N through PM + AMC. Maximum number of capsules per plant was recorded in Control (100% RDF- 87:75:50 kg NPK/ha) may be due to better uptake of nutrients and effective utilization of RDF through chemical fertilizers as reported by Anwar et al. [10] in french basil. Application of organic manures like Vermicompost and FYM was found to increase available NPK and micronutrients resulting in increased pod yield [11] in Black pepper. Biofertilizers (AMC) increases the production of growth hormones *viz.,* IAA, GA and Dehydrozeatin which in turn resulted in maximum number of capsules [12] in Pepper. Similar results have been reported by Ramesh [13] in aswagandha and Chandana et al. [4] in kalmegh.

3.1.6 Seed yield per plot (g)

The data from Table 1 also revealed that significantly maximum seed yield per plot (5.18 g) was observed with T_{13} (100% RDF- 87:75:50

kg NPK/ha) followed by T_6 (75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC) (3.91 g), T10 (50 % N through VC + 25 % N through NC + 25 % N through PM + AMC) (3.84 g), T_5 (75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC) (3.76 g). The minimum seed yield per plot (3.43 g) was recorded with T_4:100 % N through PM + AMC.

Maximum seed yield/plot was recorded in Control (100 % RDF- 87:75:50 kg NPK/ha). More number of capsules also one of the reason for more seed yield. The combined application of organic manures and biofertilizers (AMC) might have supplied adequate amounts of nutrients, which favoured higher metabolic rate and auxin activities in the plant, resulting in better yield attributes and higher seed yield. This is in accordance with the findings of Manohar et al. [14] and Ramesh [13] in aswagandha and Chandana et al. (2019) in kalmegh.

3.2 Economics

3.2.1 Benefit cost ratio

The economics as influenced by the effect of organic manures and biofertilizers has been calculated and presented in Table 2 and 3. Among the treatments, T_6 : 75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC recorded the highest gross returns (Rs. 96,400/ha), net returns (Rs. 47,348/ha) with benefit cost ratio of 0.97, followed by T_{13} : Control

able 1. Effect of organic manures and biofertilizers on yield parameters of kalmegh

Treatments	Fresh herb yield/plot(kg)	Dry herb yield/plot (kg)	Fresh herb yield/ha (q)	Dry herb yield/ha (q)	Number of capsules/plant	Seed yield/plot (g)
T_1	1.86	0.791	36.94	15.64	271.34	3.54
T_2	2.15	0.878	42.91	17.29	280.19	3.60
T_3	2.07	0.861	41.10	16.84	266.12	3.52
T_4	1.78	0.665	35.31	13.07	254.01	3.43
T_5	2.33	0.927	46.28	18.19	309.54	3.76
T_6	2.52	0.981	49.45	19.28	334.23	3.91
T_7	2.13	0.870	42.62	17.17	286.87	3.60
T_8	1.81	0.740	35.93	14.60	281.09	3.48
T_9	2.27	0.900	45.30	17.72	300.21	3.64
T_{10}	2.46	0.958	48.89	18.77	317.13	3.84
T_{11}	2.11	0.867	41.87	17.21	309.63	3.56
T_{12}	1.98	0.818	39.45	16.42	297.17	3.69
T_{13}	3.29	1.226	64.21	24.27	400.02	5.18
S.Em±	0.12	0.035	1.76	0.72	10.70	0.08
C.D.at 5%	0.36	0.102	5.14	1.47	31.22	0.25

Table 2. Effect of organic manures and biofertilizers on economics of kalmegh

Treatments	Total cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1	49222	78200	28978	0.59
T_2	49022	86450	37428	0.76
T_3	57722	84200	26478	0.46
T_4	40622	65350	24728	0.61
T_5	50252	90950	40698	0.81
T_6	49052	96400	47348	0.97
T_7	54442	85850	31408	0.58
T_8	42762	73000	30238	0.71
T_9	51197	88600	37403	0.73
T_{10}	49097	93850	44753	0.91
T_{11}	51322	86050	34728	0.68
T_{12}	45872	82100	36228	0.79
T_{13}	37250	72810	35560	0.95

Table 3. Effect for organic manures and biofertilizers on fixed cost, variable cost and dry herb selling price of kalmegh in Rs/kg

Treatments	Fixed cost (Rs/ha)	Variable cost (Rs/ha)	Dry herb selling Price in Rs/kg
T_1	30250	18972	50
T_2	30250	18772	50
T_3	30250	27472	50
T_4	30250	10372	50
T_5	30250	20002	50
T_6	30250	18802	50
T_7	30250	24192	50
T_8	30250	12512	50
T_9	30250	20947	50
T_{10}	30250	18847	50
T_{11}	30250	21072	50
T_{12}	30250	15622	50
T_{13}	30250	7000	30

Note: As organic kalmegh produce fetches higher market price than inorganic kalmegh their was different selling price

(100% RDF- 87:75:50 kg NPK/ ha) (0.95), T10 : 50 % N through VC + 25 % N through NC + 25 % N through PM + AMC (0.91) and T_5: 75 % N through FYM + 12.5 % N through VC + 12.5 % N through NC+ AMC (0.81).

The minimum benefit cost ratio (0.46) was recorded in T_3: 100 % N through NC + AMC. The increase in benefit cost ratio was mainly due to the increased dry herbage yield as the application of organic manures in combination with biofertilizers (AMC) and due to the organic produce fetches higher price in market compare to inorganic produce, which helped in increasing the gross returns, net returns and B:C ratio. Similar results were reported by Thakur et al. [15] in sweet basil, Godara et al. [16] in coriander, Ravikumar et al. [17] in coleus and Amala et al. [18] in turmeric.

4. CONCLUSION

The yield parameters indicated that, among all treatments, T_{13}: Control (100 % RDF- 87: 75: 50 NPK kg/ha) recorded significantly highest fresh herb yield/plot (3.29 kg), dry herb yield/plot (1.226 kg), fresh herb yield/ha (64.21 q), dry herb yield/ha (24.27 q), number of capsules per plant (400.02) and seed yield/plot (5.18 g). Among the organic manures with biofertilizers, highest yield parameters were recorded with T_6: 75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC. The data on economics revealed that T_6: 75 % N through VC + 12.5 % N through NC + 12.5 % N through PM + AMC recorded the highest benefit cost ratio (0.97) over all the other treatments.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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