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Influence of organic manures and fertilizers on growth, yield and quality in kalmegh (*Andrographis paniculata* Wall. Ex. Nees.)

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Abstract
A field experiment entitled "Integrated nutrient management in kalmegh (*Andrographis paniculata* Nees.)" was conducted in late *kharif* season, 2018-19 at Main Horticultural Research and Extension Centre (MHREC), University of Horticultural Sciences, Udyanagiri, Bagalkot, to evaluate the performance of different doses of organic manures and chemical fertilizers under the prevailing conditions of Bagalkot, with 24 treatments and three replications. Among different combinations application of 25 tonnes of FYM + 1.0 tonne of vermicompost + 75:75:50 kg NPK per hectare had beneficial effect on growth, yield and quality parameters. Significantly highest plant height (65.67 cm), number of leaves (105.38), number of branches (47.97) per plant and higher fresh herbage yield (21.47 t/ha) and dry herbage yield (7.64 t/ha) were noticed. There was no significant variation in andrographolide content in plants.

Keywords: Kalmegh, growth, yield, quality, FYM, vermicompost, and NPK

Introduction
Kalmegh (*Andrographis paniculata* Nees.) whole herb contains the medicinal properties. The plant is also known as "Rice bitters" in West Indies and "King of bitters" or "Chiretta" in England because of its similarity in appearance and bitter taste as that of neem (*Azadirachta indica* A. Juss) though it is much smaller in size (Niranjan *et al.,* 2010) [4]. It is an active constituent in majority of Ayurvedic preparations and is official in the Ayurvedic Pharmacopoeia (Rammohan *et al.,* 2011) [7]. The herb is being used mainly for treating fever, liver diseases, diabetes, snakebite. Recent experimental finding indicated that kalmegh is having antityphoid and antibiotic properties (Oudhia, 2002) [5]. Therefore, balanced application of nutrients is an important factor for obtaining higher growth, yield and quality attributes but there is lack of information on integrated nutrient management in kalmegh. Therefore, present investigation was under taken on integrated nutrient management in kalmegh.

Materials and Methods
A field experiment was conducted at Main Horticultural Research and Extension Centre (MHREC), University of Horticultural Sciences, Udyanagiri, Bagalkot, India, in late *kharif* season, 2018-19 on calcarious soil having soil pH (8.01), available nitrogen (249 kg/ha), phosphorus (24.12 kg/ ha) and potassium (496.92 kg/ha), organic carbon (0.33%), electrical conductivity (0.51 ds/m^2). The mean temperature of experimental site was 21.14 ^{0}C to 31.64 ^{0}C, relative humidity 45.14 to 69.81 per cent and rain fall was 0.92 mm. Experiment was consisted 24 treatments and three replication having plot size of 1x1.5m^2, three main factors having different levels in which 4 levels of nitrogen, phosphorous and potassium (F_0, F_1, F_2 and F_3, respectively), 3 levels of FYM (M_1, M_2 and M_3, respectively) and 2 levels of vermicompost (V_1 and V_2, respectively). The variety CIM-Megha was collected from CIMAP, Lucknow and sown.

Treatment combinations
1. $M_0V_0F_0$ 7. $M_1V_0F_0$ 17.$M_2V_0F_0$
2. $M_0V_0F_1$ 8. $M_1V_0F_1$ 18.$M_2V_0F_1$
3. $M_0V_0F_2$ 9. $M_1V_0F_2$ 19.$M_2V_0F_2$
4. $M_0V_0F_3$ 10.$M_1V_0F_3$ 20.$M_2V_0F_3$

5. $M_0V_1F_0$ 11.$M_1V_1F_0$ 21.$M_2V_1F_0$
6. $M_0V_1F_1$ 12.$M_1V_1F_1$ 22.$M_2V_1F_1$
7. $M_0V_1F_2$ 15.$M_1V_1F_2$ 23. $M_2V_1F_2$
8. $M_0V_1F_3$ 16.$M_1V_1F_3$ 24. $M_2V_1F_3$

During kharif season (August 04 2018). Full dose of FYM (farm yard manure) and vermicompost applied one week before sowing and mixed well, at the time of sowing applied half dose of nitrogen, full dose of phosphorus in the form of single super phosphate (P_2O_5) and potash in the form of muriate of Potash (K_2O) and remaining 50% of N was applied at 30 DAS to respective treatment combinations. Healthy seeds of variety CIM-Megha were selected for sowing. Before sowing, the seeds were mixed with sand (1:10). The crop was line sown at a depth of 1-2 cm by maintaining 15x15 cm spacing between row to row and plant to plant. Light irrigation was provided immediately after sowing. The growth parameters were recorded at 30, 60, 90 DAS and at harvest (120 DAS) on five randomly selected plants in each plot from three replications. While harvesting the whole plants were cut by leaving 10 cm above ground level and shade dried for dry herbage yield and the dry yield per hectare was estimated on the basis of dry herbage yield per plot and it was reduced by 10 per cent considering path, irrigation chnnels in the field. The dry herbage yield per hectare was expressed in terms of tonnes.

Calculations, calibration curves and linearity

For both the plants, the respective analysis have been carried out on the following instrumentation, Reverse phase - ultra fast liquid chromatograpy - photo diode array (RP-UFLC-PDA) analysis was performed on Shimadzu chromatographic system (Model no. LC-20AD) consisting of a quaternary pump, manual injector, degasser (DGU-20A5) and dual λ UV absorbance diode array detector SPD-M20A. The built in LC Solution software system was used for data processing. RP-UFLC analysis was carried out following ICH guidelines.

- Andrographolide standard was accurately weighed separately and dissolved in Acetonitrile to prepare 1000 PPM (µg /mL) and diluted with acetonitrile to obtain working concentrations for plotting calibration curves.
- Ten different concentration levels of stock solution (250.00, 125.00, 62.50, 31.25, 15.63, 7.81, 3.91, 1.95, 0.98 and 0.49 µg /mL) were used during the study.

Result and Discussion

Growth, yield and quality characters increased as the crop was supplied with both organic and inorganic fertilizers (FYM + vermicompost + NPK).

Growth parameters

Among different treatment combinations $M_2V_1F_3$ (FYM @ 25 t/ha + vermicompost @ 1 t/ha + NPK @ 75:75:50 kg/ha) showed significantly highest plant height (65.67 cm) followed by $M_1V_0F_3$ (64.83 cm), maximum number of leaves (105.38) which found to be on par with $M_2V_0F_3$ (100.80) and maximum number of branches (47.97) followed by $M_1V_0F_3$ (45.97) (Table 1) were noticed whereas, the lowest plant height (25.13 cm), minimum number of leaves (36.00) and branches (8.97) were noticed in $M_0V_0F_0$ (FYM @ 25 t/ha + vermicompost @ 0 t per ha + NPK @ 0: 0: 0 kg t per ha).

This might be due to balanced application of organic manures in combination with inorganic fertilizers could be ascribed to improvement in soil health and supplied both macro and micro nutrients to the crop or it might be due to fact that nutrient released from both organics and inorganic fertilizers would have resulted in the increased nutrient availability which inturn enhanced the translocation of photosynthates and improved vegetative growth. These results corroborate with the findings of Nadukeri (2006) [3] in coleus.

Yield parameters

Significantly higher fresh herbage yield (21.47 t/ha) in $M_2V_1F_3$ (FYM @ 25 t/ha + vermicompost @ 1 t/ha + NPK @ 75:75:50 kg/ha) followed by $M_2V_0F_3$ (18.87 t/ha) and dry herbage yield (7.64 t/ha) in $M_2V_1F_3$ (FYM @ 25 t/ha + vermicompost @ 1 t/ha + NPK @ 75:75:50 kg/ha) which found to be on par with $M_2V_1F_2$ (6.90 t/ha) (Table 2) whereas, the lower fresh herbage yield (7.71 t/ha) and dry herbage yield (2.52 t/ha) were noticed with FYM at 0 t per ha + vermicompost at 0 t per ha + 0: 0: 0 kg NPK per ha ($M_0V_0F_0$).

Table 1: Influence of integrated nutrient management on plant height, number of leaves and number of branches at harvest in kalmegh

Treatment		Plant height (cm)					Number of leaves					Number of branches				
		F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean
M_0	V_0	25.13	41.67	36.27	44.67	36.94	36.00	50.13	52.53	67.33	51.50	8.97	20.93	21.17	39.97	22.76
	V_1	39.34	30.87	43.07	45.00	39.57	48.00	47.33	60.33	76.20	57.97	15.57	23.17	30.47	29.90	24.78
	Mean	32.24	36.27	39.67	44.84	38.25	42.00	48.73	56.43	71.77	54.73	12.27	22.05	25.82	34.94	23.77
M_1	V_0	39.63	51.80	33.72	64.83	47.50	49.67	45.67	56.27	100.40	63.00	21.37	17.17	24.17	45.97	27.17
	V_1	32.07	64.67	57.33	46.53	50.15	56.53	62.43	81.87	79.80	70.16	11.77	24.00	33.30	30.17	24.81
	Mean	35.85	58.24	45.53	55.68	48.82	53.10	54.05	69.07	90.10	66.58	16.57	20.59	28.74	38.07	25.99
M_2	V_0	55.27	58.67	28.43	47.07	47.36	46.67	62.13	61.20	100.80	67.70	14.27	32.17	24.77	43.30	28.63
	V_1	36.48	49.07	50.00	65.67	50.31	56.40	86.47	87.07	105.38	83.83	30.37	32.00	36.07	47.97	36.60
	Mean	45.88	53.87	39.22	56.37	48.83	51.54	74.30	74.14	103.09	75.77	22.32	32.09	30.42	45.64	32.62
Mean of fertilizer (F)		37.99	49.46	41.47	52.30	45.50	48.88	59.03	66.55	88.32	65.69	17.05	24.91	28.33	39.55	27.46
Mean of (V)	V_0	40.01	50.71	32.81	52.19	43.93	44.11	52.64	56.67	89.51	60.73	14.87	23.42	23.37	43.08	26.19
	V_1	35.96	48.20	50.13	52.40	46.68	53.64	65.41	76.42	87.13	70.65	19.24	26.39	33.28	36.01	28.73

For comparing means of	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%
FYM (M)	0.87	2.47	1.22	3.47	0.37	1.05
Vermicompost (V)	0.71	2.02	0.99	2.83	0.30	86.00
Fertilizer (F)	1.00	2.86	1.41	4.00	0.43	1.21
M x V	1.23	3.50	1.72	4.90	0.52	1.48
M x F	1.74	4.95	2.43	6.93	0.74	2.10
V x F	1.42	4.04	1.99	5.66	0.60	1.71
M x V x F	2.46	7.00	3.44	9.80	1.04	2.97

Farm yard manure (M)
M0 = 0 t ha-1
M1= 12.5 t ha-1
M2= 25 t ha-1

Vermicompost (V)
V0= 0 t ha-1
V1 = 1 t ha-1

Fertilizers (F)
F0= 0:0:0 NPK (kg ha-1)
F1 = 25:25:30 NPK (kg ha-1)
F2 = 50:50:40 NPK (kg ha-1)
F3 = 75:75:50 NPK (kg ha-1

DAS = Days after sowing
NS = Non significant

Table 2: Influence of integrated nutrient management on fresh herbage yield and dry herbage yield in kalmegh

Treatment		Fresh herbage yield per hectare (t)					Dry herbage yield hectare (t)				
		F_0	F_1	F_2	F_3	Mean	F_0	F_1	F_2	F_3	Mean
M_0	V_0	7.71	10.64	11.38	13.66	10.85	2.52	2.08	2.89	3.20	2.67
	V_1	8.54	11.93	13.92	13.38	11.94	1.82	2.16	2.90	3.22	2.53
	Mean	8.13	11.29	12.65	13.52	11.40	2.17	2.12	2.90	3.21	2.60
M_1	V_0	10.45	10.57	12.55	16.81	12.60	2.30	2.90	2.90	4.10	3.05
	V_1	8.97	11.93	16.60	12.72	12.56	3.30	4.50	4.90	4.58	4.32
	Mean	13.92	11.25	14.58	14.77	13.63	2.80	3.70	3.90	4.34	3.69
M_2	V_0	8.04	13.20	11.92	18.87	13.01	3.43	5.68	4.23	6.90	5.06
	V_1	10.79	14.66	14.71	21.47	15.41	3.52	4.47	6.63	7.64	5.57
	Mean	12.32	13.93	13.32	20.17	14.93	3.48	5.08	5.43	7.27	5.31
Mean of fertilizer (F)		9.87	12.16	13.51	16.15	12.92	2.82	3.63	4.08	4.94	3.87
Mean of (V)	V_0	8.73	11.47	11.95	16.45	12.15	2.75	3.55	3.34	4.73	3.59
	V_1	9.43	12.84	15.08	15.86	13.30	2.88	3.71	4.81	5.15	4.14

For comparing means of	S.Em ±	C.D @ 5%	S.Em ±	C.D @ 5%
FYM (M)	0.28	0.80	0.14	0.39
Vermicompost (V)	0.23	0.65	0.11	0.32
Fertilizer (F)	0.32	0.92	0.16	0.46
M x V	0.40	1.13	0.20	0.56
M x F	0.56	1.60	0.28	0.79
V x F	0.46	1.30	0.23	NS
M x V x F	0.79	2.26	0.39	1.12

Farm yard manure (M)
M_0 = 0 t ha^{-1}
M_1= 12.5 t ha^{-1}
M_2= 25 t ha^{-1}

Vermicompost (V)
V_0= 0 t ha^{-1}
V_1 = 1 t ha^{-1}

Fertilizers (F)
F_0= 0:0:0 NPK (kg ha^{-1})
F_1 = 25:25:30 NPK (kg ha^{-1})
F_2 = 50:50:40 NPK (kg ha^{-1})
F_3 = 75:75:50 NPK (kg ha^{-1})

DAS = Days after sowing
NS = Non significant

This might be due to higher dry matter accumulation in plant parts and which had the positive effect on crop growth rate and quality. These results are in line with the findings of Kattimani (1999) [2] in Japanese mint, Arul (2002) [1] in ashwagandha and Rajwade *et al*. (2000) [6] in potato.

Conclusions

Present investigation concluded that combination of FYM at 25 t per ha + vermicompost at 1 t per ha + NPK at 75: 75: 50 kg per ha ($M_2V_1F_3$) showed significantly high dry herbage yield (7.64 t/ha), andrographolide content (3.63%) and maximum benefit cost ratio (3.29).

Along with the above treatment combinations, $M_2V_0F_3$ also performed better with the combination of FYM at 25 t per ha + vermicompost at 0 t per ha + NPK at 75: 75: 50 kg per ha ($M_2V_0F_3$) showed significantly high dry herbage yield (6.69 t/ha), andrographolide content (2.50%) and maximum benefit cost ratio (2.97).

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