Ann. For. Res. 65(1): 7633-7641, 2022
ISSN: 18448135, 20652445

ANNALS OF FOREST RESEARCH
https://www.e-afr.org/

RESPONSE TO ORGANIC MANURES AND PLANT GEOMETRY IN KALMEGH (*ANDROGRAPHIS PANICULATA* NEES.) : WAY TO REDUCE EXPLOITATION OF FOREST

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Abstract

The experiment was taken at department of Plantation, Spice, Medicinal and Aromatic Crops, College of Horticulture, RVSKVV, Mandsaur (M.P.) during 2019-20 in factorial RBD design replicated thrice with two organic manures along with control and three plant spacing. Result revealed that vermicompost @ 3 t ha^{-1} had higher plant height (13.89, 31.16, 44.71, 55.37 and 55.58 cm), number of primary branches (6.85, 9.50, 13.41, 15.28 and 15.37), chlorophyll content (16.97, 31.51, 45.92 and 54.89), leaf area (8.42, 49.28, 107.75, 135.46 and 135.57), fresh weight (10.28, 20.05, 45.14, 83.91 and 83.95) and dry weight (0.63, 4.47, 9.52, 33.19 and 33.24) over other organic manures, similarly 30×30 cm had maximum plant height (13.75, 30.73, 43.84, 53.37 and 53.67), number of primary branches (6.19, 8.34, 12.26, 14.14 and 14.26) chlorophyll content (16.12, 30.09, 44.29 and 52.52), leaf area (7.99, 46.96, 106.88, 133.71 and 133.88), fresh weight (10.28, 19.58, 43.96, 83.21 and 83.25) and dry weight (0.62, 4.38, 9.43, 32.41 and 32.46) among the other spacing. In the interaction of vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing shown similar finding at 30, 60, 90, 120 DAT and harvest, respectively.

Introduction

Kalmegh (*Andrographis paniculata*) is an important annual medicinal plant of family Acanthaceae being used in Indian system of medicines since time immemorial. The plant is also known as king of bitters. It is native to India, Sri Lanka and distributed throughout Thailand, Peninsular Malaysia to Indonesia also In India it is cultivated the state of Madhya Pradesh, Chhattisgarh, Odisha, Maharashtra, Assam, Bihar, West Bengal, Uttar Pradesh, Tamil Nadu and Kerala. The genus *Andrographis* consists of 28 species out of which few species are medicinally used and *A. paniculata* is most popular. The plant grows erect to a height of 30 to 110 cm with lance shaped leaves and small flowers. The herb is having a preventive effect from many diseases, due to its powerful immune strengthening benefits. The demand of kalmegh is increasing day by day (Chauhan *et al.* 2021). Organic farming provides several benefits to the growers. It reduces production cost and it is an environmentally friendly way of cultivation for improvement of soil fertility and biological properties particularly with vermicompost (Chandravanshi et al., 2021).

Significant correlation between the soil properties and yield and bioactive compound content indicates that organic sources have beneficial impact on yield and quality of kalmegh through improving soil properties (Basak *et al.* 2019). Spacing is an important factor for better growth and yield of the plant. Optimum number of plants is required per unit area to utilize efficiently the available production factors such as water, nutrient, light and CO_2. Maximum exploitation of these factors is achieved when the plant population puts forth maximum pressure on all the factors of production.

Materials and Methods

The present study was carried out with the soil application of different organic manures and plant spacing at department of Plantation, Spice, Medicinal and Aromatic Crops, College of Horticulture Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during 2019-20 in factorial RBD design with replicated thrice. Experimental site is situated in Malwa plateau in Western part of Madhya Pradesh at 23.450 to 24.130 North latitude, 74.440 to 75.180 East longitudes and belongs to sub-tropical and semi-arid climatic conditions. The treatments accompanied with three main plots (organic manures) as vermicompost @ 3 T, neem cake @ 5 T ha^{-1} with one control and three sub plots (spacing) as 30×15, 30×30 and 30×45 cm. During the experimentation all the morphological and growth parameters were recorded at 30, 60, 90, 120 DAT & at harvest and were statistically analyzed by using the technique suggested by Panse and Sukhatme (1985) on the mean basis. Where the "F" test was found significant at 5 % and the critical differences for the treatment's comparison were worked out.

Results and discussions

The result revealed that the application of different organic manures and spacing were significantly influenced the morphological and growth parameters.

Morphological and Growth parameters

Effect of organic manure's

The data pertaining that the vermicompost @ 3 t ha^{-1} had higher plant height (13.89, 31.16, 44.71, 55.37 and 55.58 cm), number of primary branches (6.85, 9.50, 13.41, 15.28 and 15.37), chlorophyll content (16.97, 31.51, 45.92 and 54.89), leaf area (8.42, 49.28, 107.75, 135.46 and 135.57), fresh weight (10.28, 20.05, 45.14, 83.91 and 83.95) and dry weight (0.63, 4.47, 9.52, 33.19 and 33.24) followed by neem cake @ 5 t ha^{-1} at 30, 60, 90, 120 DAT and harvest, respective. The finding of Semwal *et al.* (2016) supported with our conclusions that, the vermicompost stimulates availability of oxygen, maintains normal soil temperature, increased water holding capacity and availability of nutrients which is the reason for increases growth. The vegetative growth in kalmegh may be due to an increase in activity of enzymes like proteases and chitinases which break down the organic-rich compounds. The events of micro flora and micro fauna population in the soil which increases the availability of macro and micro-nutrients especially through application of vermicompost (Shahjahan *et al.,* 2013).

Effect of plant geometry

In the sub treatment 30×30 cm had maximum plant height (13.75, 30.73, 43.84, 53.37 and 53.67), number of primary branches (6.19, 8.34, 12.26, 14.14 and 14.26) chlorophyll content (16.12, 30.09, 44.29 and 52.52), leaf area (7.99, 46.96, 106.88, 133.71 and 133.88), fresh weight (10.28, 19.58, 43.96, 83.21 and 83.25) and dry weight (0.62, 4.38, 9.43, 32.41 and 32.46) but 30x15 cm spacing was logged behind the former over rest of the spacing at 30, 60, 90, 120 DAT and harvest, respective.. The wider spacing will increase the accessibility of water, nutrients to individual plants and receive more light than plants with a narrow spacing. These plants produced more leaves than the less one. So that the overall growth and chlorophyll content of the plant increases. The investigation is in agreement with the findings of Sanjutha *et al.* 2008 and Tapre *et al.*, 2018. Similarly, sunlight is a major aspect for the photosynthesis process, resulting in accumulation of more photosynthates which is responsible for higher dry matter production (Shambhu et al, 2019).

Effect of interaction's

In the interaction of vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing was recorded significant maximum plant height (14.07, 32.26, 46.08, 57.76 and 58.00), number of primary branches (8.17, 10.95, 14.98, 16.86 and 16.96), chlorophyll content (SPAD) (18.67, 33.50, 49.52 and 57.27), leaf area (9.30, 51.44, 110.23, 138.10 and 138.28), fresh weight (10.31, 21.36, 47.80 84.99 and 85.04) and dry weight (0.64, 4.84, 9.89, 34.93 and 34.97) at 30, 60, 90, 120 DAT and harvest, respective over rest of the combinations. This might be due to the higher uptake of nutrients especially iron and magnesium from applied vermicompost in soil and wider spacing, resulting in greater photosynthetic area and therefore overlong and wider leaves Verma *et al.,* 2018). The increased growth parameters were recorded with organic manures in combination with in wider spacing over the no fertilizer and closer spacing. The investigation is in agreement with the findings of Chandana *et al.* (2018). The application of varying levels of organic manures and different spacing had significantly increased the total dry weight production (Tapre *et al.,* 2018) and (Park *et al.* 2019).

Yield and yield parameters

In the present study it was observed that application of different organic manure and spacing was significantly influence the yield and yield parameters of kalmegh.

Effect of organic manures

The investigation revealed that, vermicompost @ 3 t ha^{-1} produced more number of pods (68.86), number of seeds (9.47), pod length (1.85), pod dry weight (23.22) and seed yield of (63.54) followed by neem cake @ 5 t ha^{-1} as compared to no fertilizers at 30, 60, 90, 120 DAT and harvest, respective. This might be possible because the application of vermicompost which improves soil physical and chemical property and most important to the adequate supply of nutrients to the plants which is directly responsible to promote the vegetative growth. Similar findings were reported by (Chandana et al., 2021 and Basak *et al.,* 2019). On the other hands, the vermicompost enhanced the activity of beneficial microbes, which play a significance role in fixation and mobilization of available nutrients in soil, resulted in better yield and related traits Sanjutha *et al.* (2008).

Effect of geometry

In the spacing 30×30 cm had obtained maximum number of pods (66.43), number of seeds (9.24), pod length (1.81), pod dry weight (22.08) and seed yield (61.92) at 30, 60, 90, 120 DAT and harvest, respective over the remaining treatments. Shanbhu *et al.* (2019) reported that wider spacing shown less competition for light, air, space and nutrients also which ultimately enhanced plant growth and yield. Similarly, reported (Chandana *et al.,* 2018).

Effect of interactions

Combinations of vermicompost @ 3 t ha^{-1} with 30×30 cm spacing recorded significantly maximum number of pods (70.93), number of seeds (9.73), pod length (1.94), pod dry weight (24.33) and seed yield (66.59) at 30, 60, 90, 120 DAT and harvest, respective among the combinations. The improvement in the physical and biological conditions on account of addition of organics and suitable planting geometry, which also would have facilitated better absorption of nutrients from the soil, might be the reason for increased yield attributes according to Sanjeev *et al.* (2013). This might be possible because the application of organic manure in the form of vermicompost in combination with suitable plant geometry and most important to the adequate supply of nutrients to the plants which is directly responsible to promote the vegetative growth. Similar findings were reported by (Nayma et al., 2019 and Basak *et al.,* 2019), Shahjahan *et al.,* 2013 and Sanjeev *et al.,* 2013.

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Ann. For. Res. 65(1): 7633-7641, 2022
ISSN: 18448135, 20652445

Table 1: Effects of organic manures and plant geometry on plant height and branches of kalmegh

Treatments	Plant height (cm)					Number of primary branches (plant^{-1})				
	30 DAT	60 DAT	90 DAT	120 DAT	At harvest	30 DAT	60 DAT	90 DAT	120 DAT	At harvest
Main plot (Organic manures T ha^{-1})										
M_0 (No fertilizer)	13.38	28.24	38.24	44.43	44.66	3.58	4.74	8.60	10.48	10.59
M_1-Vermicompost (3)	13.89	31.16	44.71	55.37	55.58	6.85	9.50	13.41	15.28	15.37
M_2 -Neem cake (5)	13.64	30.28	43.83	53.08	53.45	5.50	7.48	11.34	13.22	13.38
S. Em. ±	**0.02**	**0.12**	**0.21**	**0.28**	**0.30**	**0.13**	**0.24**	**0.23**	**0.22**	**0.22**
C.D. at 5%	**0.06**	**0.37**	**0.64**	**0.85**	**0.90**	**0.40**	**0.70**	**0.68**	**0.67**	**0.66**
Sub plot (Spacing cm)										
S_1 (30x15)	13.49	29.01	40.22	47.92	48.15	4.22	5.87	9.73	11.59	11.78
S_2 (30x30)	13.75	30.73	43.84	53.37	53.67	6.19	8.34	12.26	14.14	14.26
S_3 (30x45)	13.67	29.93	42.72	51.59	51.87	5.53	7.51	11.37	13.25	13.30
S.Em. ±	**0.02**	**0.14**	**0.25**	**0.33**	**0.35**	**0.15**	**0.27**	**0.26**	**0.26**	**0.25**
C.D. at 5%	**0.07**	**0.43**	**0.74**	**0.98**	**1.04**	**0.46**	**0.81**	**0.79**	**0.77**	**0.76**
Interactions (Organic manure x Spacing)										
M_0S_1	13.32	27.93	36.55	42.44	42.66	2.68	4.23	8.09	9.98	10.03
M_0S_2	13.44	28.69	39.87	46.62	46.84	4.33	5.26	9.13	11.01	11.17
M_0S_3	13.39	28.09	38.31	44.23	44.49	3.72	4.73	8.59	10.47	10.58
M_1S_1	13.62	29.60	42.77	51.51	51.70	5.15	7.35	11.21	13.03	13.32
M_1S_2	14.07	32.26	46.08	57.76	58.00	8.17	10.95	14.98	16.86	16.96
M_1S_3	13.97	31.61	45.77	56.84	57.03	7.25	10.20	14.06	15.95	15.82

M_2S_1	13.53	29.49	41.33	49.82	50.09	4.83	6.03	9.89	11.78	11.97
M_2S_2	13.73	31.25	45.58	55.73	56.18	6.06	8.81	12.67	14.56	14.65
M_2S_3	13.64	30.10	44.09	53.69	54.08	5.61	7.61	11.47	13.32	13.50
S.Em. ±	**0.03**	**0.20**	**0.35**	**0.46**	**0.49**	**0.22**	**0.38**	**0.37**	**0.36**	**0.36**
C.D. at 5%	**0.10**	**0.60**	**1.04**	**1.38**	**1.47**	**0.65**	**1.15**	**1.11**	**1.09**	**1.07**

Table 2: Effects of organic manures and plant geometry on fresh and dry weight of kalmegh

Treatments	**Fresh Weight (g plant^{-1})**					**Dry weight (g plant^{-1})**				
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**At harvest**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**At harvest**
Main plot (Organic manures T ha^{-1})										
M_0 -No fertilizer	10.23	16.97	38.84	76.91	76.99	0.55	3.88	8.49	29.66	29.71
M_1 - Vermicompost (3)	10.28	20.05	45.14	83.91	83.95	0.63	4.47	9.52	33.19	33.24
M_2 -Neem cake (5)	10.27	19.00	43.34	83.10	83.16	0.61	4.23	9.28	31.26	31.32
S.Em. ±	**0.00**	**0.13**	**0.33**	**0.40**	**0.40**	**0.00**	**0.05**	**0.05**	**0.18**	**0.18**
C.D. at 5%	**0.01**	**0.39**	**0.98**	**1.19**	**1.20**	**0.01**	**0.16**	**0.14**	**0.55**	**0.54**
Sub plot (Spacing cm)										
S_1 (30x15)	10.24	17.57	40.56	79.47	79.52	0.57	3.97	8.64	30.19	30.24
S_2 (30x30)	10.28	19.58	43.96	83.21	83.25	0.62	4.38	9.43	32.41	32.46
S_3 (30x45)	10.26	18.86	42.79	81.25	81.32	0.60	4.23	9.23	31.51	31.57
S.Em. ±	**0.00**	**0.15**	**0.38**	**0.46**	**0.46**	**0.00**	**0.06**	**0.06**	**0.21**	**0.21**
C.D. at 5%	**0.01**	**0.44**	**1.13**	**1.38**	**1.39**	**0.01**	**0.18**	**0.17**	**0.63**	**0.63**
Interactions (Organic manure x Spacing)										
M_0S_1	10.20	16.15	37.69	74.83	74.90	0.51	3.78	7.87	29.11	29.15
M_0S_2	10.25	17.52	39.81	80.38	80.42	0.58	3.97	8.89	30.17	30.22

M_0S_3	10.23	17.25	39.01	75.53	75.65	0.57	3.89	8.72	29.71	29.77
M_1S_1	10.26	18.57	42.35	81.91	81.94	0.61	4.08	9.05	30.84	30.89
M_1S_2	10.31	21.36	47.80	84.99	85.04	0.64	4.84	9.89	34.93	34.97
M_1S_3	10.28	20.20	45.27	84.83	84.88	0.64	4.48	9.63	33.79	33.85
M_2S_1	10.26	17.99	41.64	81.68	81.73	0.59	4.06	8.99	30.61	30.66
M_2S_2	10.27	19.86	44.28	84.24	84.30	0.63	4.33	9.51	32.14	32.20
M_2S_3	10.27	19.14	44.09	83.38	83.44	0.61	4.32	9.33	31.04	31.09
S.Em. ±	**0.00**	**0.21**	**0.53**	**0.65**	**0.66**	**0.01**	**0.09**	**0.08**	**0.30**	**0.30**
C.D. at 5%	**0.01**	**0.63**	**1.60**	**1.94**	**1.97**	**0.02**	**0.26**	**0.24**	**0.89**	**0.88**

Table 3: Effects of organic manures and plant geometry on chlorophyll content and leaf area of kalmegh

Treatments	**Chlorophyll content (SPAD)**				**Leaf area (cm^{-2} $plant^{-1}$)**				
	30 DAT	**60 DAT**	**90 DAT**	**120 DAT**	**30 DAT**	**60 DAT**	**90 DAT**	**120 DAT**	**At harvest**
Main plot (Organic manures)									
M_0 (No fertilizer)	12.83	25.63	39.86	44.56	6.28	40.11	101.72	125.12	125.27
M_1(Vermicompost @ 3 t ha^{-1})	16.97	31.51	45.92	54.89	8.42	49.28	107.75	135.46	135.57
M_2 (Neem cake @ 5 t ha^{-1})	15.77	30.04	45.55	51.90	7.59	46.66	105.85	133.09	133.19
S.Em. ±	**0.23**	**0.32**	**0.32**	**0.24**	**0.07**	**0.31**	**0.21**	**0.26**	**0.24**
C.D. at 5%	**0.69**	**0.97**	**0.96**	**0.72**	**0.20**	**0.93**	**0.64**	**0.78**	**0.73**
Sub plot (Spacing cm)									
S_1 (30x15)	13.93	27.72	41.54	47.77	6.67	43.34	102.68	128.15	128.24
S_2 (30x30)	16.12	30.09	44.29	52.52	7.99	46.96	106.88	133.71	133.88
S_3 (30x45)	15.52	29.38	45.49	51.06	7.64	45.76	105.77	131.82	131.91
S.Em. ±	**0.27**	**0.37**	**0.37**	**0.28**	**0.08**	**0.36**	**0.25**	**0.30**	**0.28**
C.D. at 5%	**0.80**	**1.12**	**1.11**	**0.83**	**0.23**	**1.07**	**0.74**	**0.90**	**0.84**
Interactions (Organic manure x Spacing)									
M_0S_1	12.26	24.87	38.73	42.85	5.97	39.01	100.38	123.27	123.40
M_0S_2	13.22	26.26	40.88	46.15	6.66	40.89	103.15	127.53	127.70

M_0S_3	13.00	25.77	39.96	44.66	6.21	40.45	101.64	124.56	124.70
M_1S_1	14.93	29.19	43.22	51.65	7.06	46.10	104.12	130.97	131.05
M_1S_2	18.67	33.50	49.52	57.27	9.30	51.44	110.23	138.10	138.28
M_1S_3	17.32	31.84	48.46	55.76	8.91	50.31	108.91	137.32	137.39
M_2S_1	14.59	29.08	42.67	48.82	6.97	44.91	103.54	130.20	130.28
M_2S_2	16.46	30.99	46.08	54.13	8.02	48.56	107.26	135.50	135.65
M_2S_3	16.26	30.05	44.46	52.76	7.79	46.52	106.76	133.57	133.65
S.Em. ±	**0.38**	**0.53**	**0.52**	**0.39**	**0.11**	**0.51**	**0.35**	**0.42**	**0.40**
C.D. at 5%	**1.13**	**1.58**	**1.57**	**1.17**	**0.32**	**1.52**	**1.04**	**1.27**	**1.19**

Table 4: Effects of organic manures and plant geometry on yield attributing traits of kalmegh

Treatments	Number of pods (plant^{-1})	Number of seeds (pod^{-1})	Pod length (cm)	Pod dry weight (g plant^{-1})	Seed yield (kg ha^{-1})
Main plot (Organic manures)					
M_0 (No fertilizer)	56.40	7.93	1.64	16.24	52.04
M_1(Vermicompost @ 3 t ha^{-1})	68.86	9.50	1.85	23.16	63.54
M_2 (Neem cake @ 5 t ha^{-1})	66.20	9.35	1.76	21.51	61.07
S.Em. ±	**0.29**	**0.13**	**0.01**	**0.26**	**0.25**
C.D. at 5%	**0.88**	**0.38**	**0.03**	**0.77**	**0.75**
Sub plot (Spacing cm)					
S_1 (30x15)	60.08	8.65	1.67	17.77	55.03
S_2 (30x30)	66.43	9.26	1.81	22.08	61.92
S_3 (30x45)	64.94	8.88	1.76	21.06	59.69
S.Em. ±	**0.34**	**0.15**	**0.01**	**0.30**	**0.29**
C.D. at 5%	**1.02**	**0.44**	**0.04**	**0.89**	**0.86**
Interactions (Organic manure x Spacing)					
M_0S_1	51.39	7.36	1.60	12.79	48.90
M_0S_2	59.58	8.76	1.70	18.64	55.81
M_0S_3	58.22	7.67	1.61	17.27	51.40
M_1S_1	65.95	9.34	1.72	21.36	58.90
M_1S_2	70.93	9.61	1.94	24.33	66.59
M_1S_3	69.68	9.56	1.89	23.81	65.14
M_2S_1	62.89	9.26	1.71	19.16	57.31
M_2S_2	68.77	9.41	1.79	23.28	63.37
M_2S_3	66.93	9.40	1.77	22.09	62.54
S.Em. ±	**0.48**	**0.21**	**0.02**	**0.42**	**0.41**
C.D. at 5%	**1.44**	**0.62**	**0.06**	**1.26**	**1.22**