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Impact of different organic manures and plant geometry on growth and yield of Kalmegh

K.C. Meena[1], S. K. Shakywar[2], Om Singh*[3], Nitin Soni[4], M.K. Tripathi[5], Priyamvada Sonkar[6] and B.K. Patidar[7]

[1, 2] Department of PSMA, [3*]Department of Post Harvest Management, [4, 6]Department of Fruit Science, [5]Physics and Meteorology, [7] Department of Plant Pathology
R.V.S.K.V.V., Campus- College of Horticulture, Mandsaur, M.P., India

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ABSTRACT

The experiment was conducted at Horticulture Research Farm, College of Horticulture, R.V.S.K.V.V., Mandsuar (M.P.) during *Rabi* season of 2019-20 to study the effect of different organic manures (No fertilizer, Vermicompost @ 3 t ha^{-1} and Neemcake @ 5 t ha^{-1}) and spacing (30 × 15, 30 × 30 and 30 ×45 cm) and their interactions on growth, yield and quality characters under field condition. The research experiment was laid out in a Factorial Randomized Block Design with three replications. All the parameters were recorded at 30, 60, 90, 120 days after transplanting and at harvest. On the basis of one year research, the results revealed that the days taken to 50% flowering and days taken to maturity were significantly influenced with the application of different organic manures and spacing and their interaction. The M_1 (Vermicompost @ 3 t ha^{-1}) (43.12 and 152.89) and in the sub treatment S_2 (30×30 cm) (43.31 and 154.00) and their interaction M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) (42.13 and 150.67) were found early as phenology of kalmegh. The crop growth rate (g g^{-1} day^{-1}) was recorded maximum (1.27, 11.45, 23.16, 30.80 and 30.90) in M_1 (Vermicompost @ 3 t ha^{-1}) and in the sub treatment S_2 (30×30 cm) was recorded maximum (1.26, 11.25, 21.46, 29.98 and 30.11). Under the interaction of different treatment, crop growth rate was recorded maximum (1.32, 12.79, 26.08, 33.60 and 33.75) in the treatment combination M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing). The dry herbage yield (kg ha^{-1}) was recorded maximum (2250.67) in M_1 (Vermicompost @ 3 t ha^{-1}) and in the sub treatment S_2 (30×30 cm) was recorded maximum (2146.67). Under the interaction of different treatment, maximum (2494.00) dry herbage yield (kg ha^{-1}) was recorded in the treatment combination M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing).

Key words: *Plant geometry, Dry herbage yield, Andrographis paniculata*

Introduction

Kalmegh (*Andrographis paniculata*) is an important medicinal plant of family Acanthaceae being used in Indian system of medicines since time immemorial. *Kalmegh* is a plant which is also known as "Green Chiretta" and the "King of Bitters". It is used for various medicinal purposes and is bitter in taste. It is mainly used for liver problems as it protects the liver against damage caused by free radicals due to its antioxidant and anti-inflammatory activity. It also helps to boost immunity and is used to manage the symptoms of the common cold, sinusitis and allergies due to its antimicrobial and Immunomodulatory properties. It is good for diabetics as it is effective in lowering blood sugar levels

by increasing insulin secretion. It also helps in managing blood pressure by widening the blood vessels and increasing blood flow.

Kalmegh is native to India and Sri Lanka and it is distributed throughout Thailand, Peninsular Malaysia to Indonesia and in India it is found in the state of Madhya Pradesh, Chhattisgarh, Odisha, Maharashtra, Assam, Bihar, West Bengal, Uttar Pradesh, Tamil Nadu and Kerala. The area of *Kalmegh* production in India 462.88 hectare (Karnataka, Mizoram, Madhya Pradesh, Uttar Pradesh and Andhra Pradesh).

Organic farming provides several benefits to growers. It reduces production costs and it is an environmentally friendly method of cultivation. Soil fertility and biological properties also improved with the application of organic sources, particularly vermicompost. A significant correlation between the soil properties, yield, and bioactive compound content indicates that organic sources have a beneficial impact on the yield and quality of kalmegh by improving soil properties (Basak *et al.*, 2019). Spacing is an important factor for better growth and yield of the plant. The 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. Keeping this in view, the present investigation was conducted with the following objectives: To determine the effect of organic manures, spacing on growth, and yield of *Kalmegh.*

Materials and Methods

The experiments were conducted during winter season of 2019-2020 at Horticulture Research Farm, College of Horticulture, RVSKVV, Mandsuar (M.P.). The experimental site is situated in Malwa plateau in western part of Madhya Pradesh at north latitude of 23.45o to 24.130 and 74.44o to 75.18o east longitudes and an altitude of 435.02 meters above mean sea level. This region falls under agro climatic zone no. 10 of the state. Mandsaur belongs to sub-tropical and semi-arid climatic conditions having a temperature range of minimum 5°C and maximum 44°C in winter and summer respectively. In this area maximum rainfall is received is during mid-June to September. The average rainfall is 544.05 mm. South-West monsoon is responsible for major part of annual precipitation. The soil of experimental field is light black loamy in texture with low in availability of nitrogen, low in phosphorus and high in potassium status. In a Factorial Randomized Block Design with three replications and six treatments- Organic manure (M_o-No fertilizer, M_1-Vermicompost @ 3 t $ha^{-1}$and M_2-Neem cake @ 5 t ha^{-1}) and Spacing: (S_1-30 cm × 15 cm, S_2-30 cm × 30 cm and S_3-30 × 45 cm). Observations were recorded on various growths, morphological, bio-chemical and yield parameters at different growth stage. Five plants in each plot excluding border rows were selected at random. The selected plants were tagged for recording the observations. The observations recorded and procedures adopted during the course of investigation areplant height (cm), number of branches ($plant^{-1}$), chlorophyll content (SPAD value), leaf area (cm^2 $plant^{-1}$), leaf area index, leaf area duration (cm^{-2} days), relative growth rate (g cm^{-2} day^{-1}), crop growth rate (g cm^{-2} day^{-1}), fresh weight (g $plant^{-1}$), dry weight (g $plant^{-1}$), days to 50 % maturity, days to maturity, number of pods ($plant^{-1}$), number of seed (pod^{-1}), pod length (cm), pod dry weight (gram $plant^{-1}$), harvest index, dry herbage yield (kg ha^{-1}), seed yield (g $plant^{-1}$), seed yield (kg ha^{-1}). The data obtained on various observations for each treatment were subject to "analysis of variances" as recommended by Panse and Sukhatme (1985). The critical difference (C.D.) was calculated to assess the significance of differences between treatments, whenever the results were found significant through 'F' test, CD at 5% level of significance was determined.

Results and Discussion

Phenological Parameters

Among the phenological parameters, days to 50% flowering and days to maturity were significantly influenced by different organic manures and spacing and their combination. The result revealed that the recorded minimum number of days taken to 50 % flowering (43.12) and days to maturity (152.89) in treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was maximum in treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) had taken minimum number of days to 50 % flowering (43.31) and days to maturity (154.00), while it was maximum number days taken to 50 % flowering and days to maturity recorded in sub treatment S_1(30×15 cm). Under the different treatment combinations M_1S_2

(Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly minimum number days taken to 50 % flowering (42.13) while, the maximum number days taken to 50 % flowering (44.79) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm).Days to first flowering was significantly accelerated by Vermicompost and other organic manures, which was significantly rapid than the other treatments. This is a profound phenomenon exhibited for a longer indeterminate reproductive growth which ultimately aids to overall fresh Kalmegh yield. Moreover, Organic manure produced the flowers significantly earlier than that by commercial organic fertilizer and control. Similar findings were found by Adhikari *et al.* (2016) and Bhagora *et al.* (2021).

Growth Parameters

Leaf area index

The maximum leaf area index (0.21, 1.25, 2.45 and 2.99) recorded in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was minimum (0.17, 0.17, 2.28 and 2.74) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained maximum leaf area index (0.20, 1.24, 2.41 and 2.94) while. It was minimum (0.19, 1.18, 2.32 and 2.78) in sub treatment S_1(30×15 cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly maximum leaf area index (0.21, 1.30, 2.53 and 3.10) while, the minimum (0.17, 1.15, 2.24 and 2.71) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm) at 30, 60, 90, 120 DAT and harvest, respectively. This could be due to the higher uptake of nutrients especially iron and magnesium from the soil resulting in greater photosynthetic activity and humic acid contributed to the increased leaf area index suggested by (Kumar *et al.*, 2013). Leaf area index significantly influenced with the organic manures and wider spacing as compare to closure spacing Bhagora *et al.* (2022). Organic compost and wider spacing produced maximum number of leaves as compared to control Chouhan *et al.*, 2023. This trend was in agreement with the observation of Semwal *et al.* (2016) and Chandana *et al.* (2018).

Leaf area duration (cm^2 day^{-1})

Leaf area duration was significantly influenced with the application of different organic manures and spacing. The result revealed that the recorded maximum leaf area duration (865.57, 2355.52, 3648.23 and 4065.52) in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was minimum (695.88, 2127.57, 3402.65 and 3755.82) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained maximum leaf area duration (824.32, 2307.60, 3608.80 and 4013.80) while, it was minimum (750.07, 2190.28, 3462.38 and 3845.83) in sub treatment S_1(30×15 cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly maximum leaf area duration (911.05, 2425.05, 3724.95 and 4145.65) while, the minimum (674.60, 2090.85, 3354.75 and 3700.05) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm) at 30, 60, 90, 120 DAT and harvest, respectively. This could be due to application of organic manures and suitable planting geometry influence the physical, chemical and biological properties of soil through supplying macro and micro nutrients leading to enhance the plant growth and development, this finding were also in accordance with Basak *et al.*, 2019, Ram *et al.*, 2008 and Shakywa *et al.*, 2022.

Relative growth rate (g cm^{-2} day^{-1})

The result revealed that the recorded maximum relative growth rate (0.11, 1.07, 1.34 and 1.47) in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was minimum (0.06, 0.92, 1.23 and 1.35) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained maximum relative growth rate (0.10, 1.03, 1.33 and 1.45) while. It was minimum (0.08, 0.97, 1.26 and 1.38) in sub treatment S_1(30×15cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly maximum relative growth rate (0.13, 1.09, 1.40 and 1.52) while, the minimum (0.06, 0.89, 1.21 and 1.34) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm) at 30-60, 60-90, 90-120 DAT and 120 DAT-at harvest. The possible clarification for the positive effect of organic manures and spacing improved soil structure and enhances activities of useful soil organism that makes the plants nutritive elements readily available to the crops. Optimum number of plants is required per unit area to utilize efficiently the available production factors such as water, nutrient, light and CO_2 in the plants which ultimately improved the relative growth rate. These findings are agreements with the

Table 1. Effect of different organic manures and spacing on growth and yield of Kalmegh

Treatments	Days to 50 % flowering	Days to maturity	Dry herbage yield (kg ha^{-1})	Harvest index (%)	Seed yield (g plant^{-1})
Main plot (Organic manures)					
M_0 (No fertilizer)	44.75	158.44	1634.78	398.20	14.29
M_1 (Vermicompost @ 3 t ha^{-1})	43.12	152.89	2250.67	598.67	21.64
M_2 (Neem cake @ 5 t ha^{-1})	43.69	154.44	2106.44	406.46	19.13
S.Em. ±	0.20	0.34	27.70	6.32	0.26
C.D. at 5%	0.59	1.03	83.04	18.94	0.78
Sub plot (Spacing cm)					
S_1 (30x15)	44.60	157.11	1821.11	457.64	16.42
S_2 (30x30)	43.31	154.00	2146.67	549.35	19.73
S_3 (30x45)	43.65	154.67	2024.11	396.34	18.91
S.Em. ±	0.23	0.40	31.98	7.29	0.30
C.D. at 5%	0.68	1.19	95.88	21.87	0.90
Interactions (Organic manure x Spacing)					
M_0S_1	44.79	159.33	1518.67	358.75	12.95
M_0S_2	44.69	157.67	1718.33	424.49	15.20
M_0S_3	44.77	158.33	1667.33	411.36	14.73
M_1S_1	44.38	155.33	1988.67	524.02	18.76
M_1S_2	42.13	150.67	2494.00	647.30	23.52
M_1S_3	42.84	152.67	2269.33	624.67	22.65
M_2S_1	44.64	156.67	1956.00	490.13	17.55
M_2S_2	43.12	153.67	2227.67	576.26	20.49
M_2S_3	43.33	153.00	2135.67	153.00	19.36
S.Em. ±	0.32	0.56	45.23	10.32	0.42
C.D. at 5%	0.96	1.68	135.60	30.93	1.27

Treatments	Leaf Area Index				Leaf area duration (cm^{-2} days)			
	30-60 DAT	60-90 DAT	90-120 DAT	120 DAT-At harvest	30-60 DAT	60-90 DAT	90-120 DAT	120 - At harvest
Main plot (Organic manures)								
M_0 (No fertilizer)	0.16	1.17	2.28	2.74	695.88	2127.57	3402.65	3755.82
M_1(Vermicompost @ 3 t ha^{-1})	0.21	1.25	2.46	2.99	865.57	2355.52	3648.23	4065.52
M_2 (Neem cake @ 5 t ha^{-1})	0.20	1.21	2.39	2.89	813.85	2287.73	3584.10	3994.22
S.Em. ±	0.00	0.01	0.01	0.01	4.54	5.51	4.37	7.50
C.D. at 5%	0.01	0.02	0.03	0.03	13.61	16.51	13.10	22.47
Sub plot (Spacing cm)								
S_1 (30x15)	0.17	1.18	2.32	2.78	750.07	2190.28	3462.38	3845.83
S_2 (30x30)	0.20	1.24	2.42	2.94	824.32	2307.60	3608.80	4013.80
S_3 (30x45)	0.19	1.21	2.38	2.90	800.92	2272.93	3563.80	3955.92
S.Em. ±	0.00	0.01	0.01	0.01	5.24	6.36	5.05	8.65
C.D. at 5%	0.01	0.02	0.04	0.03	15.71	19.06	15.13	25.95
Interactions (Organic manure x Spacing)								
M_0S_1	0.13	1.15	2.24	2.71	674.60	2090.85	3354.75	3700.05
M_0S_2	0.18	1.18	2.30	2.77	713.20	2160.55	3460.15	3828.50
M_0S_3	0.17	1.17	2.29	2.73	699.85	2131.30	3393.05	3738.90
M_1S_1	0.20	1.20	2.37	2.83	797.35	2253.25	3526.40	3930.35
M_1S_2	0.22	1.30	2.54	3.10	911.05	2425.05	3724.95	4145.65
M_1S_3	0.22	1.24	2.46	3.05	888.32	2388.25	3693.35	4120.55
M_2S_1	0.20	1.18	2.36	2.81	778.25	2226.75	3506.00	3907.10
M_2S_2	0.22	1.23	2.41	2.95	848.70	2337.20	3641.30	4067.25

Table 1. *Continued ...*

Treatments	Days to 50 % flowering		Days to maturity		Dry herbage yield (kg ha^{-1})		Harvest index (%)		Seed yield (g plant^{-1})
M_2S_3	0.20	1.21	2.40	2.91	814.60	2299.25	3605.00	4008.30	
S.Em. ±	0.01	0.01	0.02	0.02	7.41	8.99	7.14	12.24	
C.D. at 5%	0.02	0.03	0.05	0.05	22.22	26.96	21.40	36.70	
Treatments	Relative growth rate (g cm^{-2} day^{-1})				Crop growth rate (g g^{-1} day^{-1})				
	30-60 DAT	60-90 DAT	90-120 DAT	120 DAT-harvest	30-60 DAT	60-90 DAT	90-120 DAT	120 DAT-harvest	
Main plot (Organic manures)									
M_0 (No fertilizer)	0.06	0.86	1.22	1.35	1.19	9.23	15.50	22.93	
M_1 (Vermicompost @ 3 t ha^{-1})	0.11	1.09	1.34	1.47	1.27	11.45	23.31	30.80	
M_2 (Neem cake @ 5 t ha^{-1})	0.09	1.04	1.31	1.43	1.24	10.75	20.61	28.88	
S.Em. ±	0.00	0.02	0.01	0.01	0.01	0.16	0.33	0.32	
C.D. at 5%	0.01	0.06	0.02	0.02	0.02	0.47	0.99	0.96	
Sub plot (Spacing cm)									
S_1 (30x15)	0.08	0.91	1.26	1.38	1.20	9.69	17.45	25.06	
S_2 (30x30)	0.10	1.05	1.33	1.45	1.26	11.25	21.46	29.98	
S_3 (30x45)	0.09	1.02	1.29	1.41	1.23	10.49	20.51	27.57	
S.Em. ±	0.00	0.02	0.01	0.01	0.01	0.18	0.38	0.37	
C.D. at 5%	0.01	0.07	0.02	0.03	0.02	0.55	1.15	1.11	
Interactions (Organic manure x Spacing)									
M_0S_1	0.06	0.68	1.21	1.34	1.17	8.98	13.71	20.88	
M_0S_2	0.07	0.97	1.25	1.37	1.20	9.60	16.54	25.99	
M_0S_3	0.06	0.92	1.21	1.34	1.19	9.11	16.24	21.91	
M_1S_1	0.09	1.06	1.29	1.42	1.23	10.05	19.88	28.08	
M_1S_2	0.13	1.12	1.40	1.52	1.32	12.79	26.08	33.60	
M_1S_3	0.10	1.09	1.34	1.48	1.27	11.50	23.96	30.73	
M_2S_1	0.08	0.99	1.28	1.38	1.22	10.03	18.75	26.22	
M_2S_2	0.10	1.06	1.34	1.47	1.25	11.36	21.76	30.35	
M_2S_3	0.09	1.06	1.32	1.43	1.25	10.86	21.32	30.08	
S.Em. ±	0.00	0.03	0.01	0.01	0.01	0.26	0.54	0.52	
C.D. at 5%	0.01	0.10	0.03	0.04	0.03	0.77	1.62	1.56	

findings of Chandana *et al.* (2018) and Thomas *et al.*, 2020.

Crop growth rate (g g^{-1} day^{-1})

The maximum crop growth rate (1.27, 11.45, 23.16, 30.80 and 30.90) recorded in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was minimum (1.19, 9.23, 15.50, 22.93 and 23.02) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained maximum crop growth rate (1.26, 11.25, 21.46, 29.98 and 30.11) while. It was minimum (1.20, 9.69, 17.45, 25.06 and 25.14) in sub treatment S_1 (30×15 cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly maximum crop growth rate (1.32, 12.79, 26.08, 33.60 and 33.75) while, the minimum (1.17, 8.98, 13.71, 20.88 and 20.96) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm) at 30, 60, 90, 120 DAT and harvest, respectively.This might be possible because the application of organic treatments and spacing significantly influenced crop growth rate. 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 Chandravanshi *et al.,* 2021. In the wider spacing plants utilize the efficiently the available production factors such as water, nutrient, light and CO_2 in the plants which ultimately improved the crop growth rate. Similar findings were reported by Chandana *et al.* (2018).

Yield Parameters

Dry herbage yield (kg ha^{-1})

Result sown that maximum dry herbage yield was recorded (2250.67) in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was minimum (1634.78) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained maximum dry herbage yield (2146.67) while, it was minimum (1821.11) in sub treatment S_1(30×15 cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly maximum dry herbage yield(2494.00) while, the minimum (1518.67) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm). The vegetative growth of the kalmegh as influenced by the use of various organic manures revealed an increase in crop yield as well as soil health (Tiwari *et al*. 2012). Organic fertilizer and spacing individually and combinedly have significant effect on growth and yield Chundawat *et al.,* 2017 of crops. Among the organic fertilizer vermicompost with wider spacing (60 x 60 cm) gave the highest total dry herbage yield (Shahjahan *et al*. 2013) and Shambhu *et al.*, 2019.

Harvest index (%)

Result sown that maximum harvest index was recorded (598.67) in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was minimum (398.20) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained maximum harvest index (549.35) while, It was minimum (457.64) in sub treatment S_1(30×15 cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly maximum harvest index (647.30) while, the minimum (358.75) was recorded in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm). Sharanya *et al.* (2018) reported that the application of organic manures with planting geometry was significantly increased the harvest index in *kalmegh* as compared to control. The response to vermicompost may contain some plant growth-stimulating substances has increase microbial activities which have enhance vegetative growth. The vermicompostmay be a potential source of nutrients, if applied in suitable ratio with appropriate plant geometry.

Seed yield (kg ha^{-1})

The study confirmed that seed yield of per plant was found highest was recorded (63.54) in main treatment M_1 (Vermicompost @ 3 t ha^{-1}) while, it was lowest (52.04) in main treatment M_0 (No fertilizer). In the sub treatment S_2 (30×30 cm) has obtained highest seed yield (61.92) while. It was lowest (55.03) in sub treatment S_1(30×15 cm). Under the different treatment combinations M_1S_2 (Vermicompost @ 3 t ha^{-1} along with 30×30 cm spacing) was recorded significantly highest seed yield (66.59) while, the lowest (48.90) in the treatment combination of M_0S_1 (No fertilizer along with 30 × 15 cm). Seed yield was increased with the application of vermicompost and closure spacing as compared to control. The vegetative growth of the *kalmegh* as influenced by the use of various organic manures (FYM and vermicompost) and planting geometry revealed an increase in crop yield as well as soil health. The investigation is and in agreement with the findings of Shahjahan *et al.,* 2013 and Srivastava, 2017.

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