Journal of Scientific Research and Reports

Volume 30, Issue 8, Page 344-349, 2024; Article no.JSRR.120529
ISSN: 2320-0227

Optimization of Kalmegh (*Andrographis paniculata* Nees.) Cultivation through Plant Spacing and Nutrient Management

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Authors' contributions

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

Article Information

DOI: https://doi.org/10.9734/jsrr/2024/v30i82255

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/120529

Original Research Article

Received: 23/05/2024
Accepted: 25/07/2024
Published: 29/07/2024

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Cite as: *U. B, Anuradha, M. G Patil, A. R. Kurubar, Shekharagouda Patil, Amaregouda N, and Ananda N. 2024. "Optimization of Kalmegh (Andrographis Paniculata Nees.) Cultivation through Plant Spacing and Nutrient Management". Journal of Scientific Research and Reports 30 (8):344-49. https://doi.org/10.9734/jsrr/2024/v30i82255.*

ABSTRACT

Kalmegh is being used form the immortal time for treating the cold, fever, snake bite, diabetics, liver diseases etc. An field experiment was conducted during *kharif* season of 2019-2020 at Horticulture Farm, Main Agricultural Research Station, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India, to study the response of plant geometry and integrated nutrient management on growth and yield of kalmegh. The experiment was laid out in a spilt plot design with 15 treatments and 3 replications. The results revealed that spacing of 30cm x 45 cm with imposition of 50% RDN + 50% vermicompost equivalent to recommended N found to be significantly higher number of primary branches and leaves per plant, leaf area and dry matter accumulation over the other treatments. The fresh and dry herbage yield per hectare were resulted in the significantly higher in the spacing of 30cm x 15 cm with the application of 50% RDN + 50% vermicompost equivalent to recommended N.

Keywords: Spacing; application; Kalmegh.

1. INTRODUCTION

India is known to be "Home for Medicinal Plants" as it grown more than 8000 species of medicinal plants. From ancient time the medicinal plants are used for treatment of many diseases by tradition knowledge (TK). Traditional knowledge (TK) associated with medicinal herbs and cultivation, innovation and preservation of medicinal herbs is a highly gendered activity in most countries. Kalmegh (*Andrographis paniculata* Nees.) belonging to family Acanthaceae which is commonly known as "King of Bitters" because of bitter taste. Its major biological activity is antidiabetic, but it has also been reported to have anti-angiogenetic, antibacterial, anti-cancer anti-infammatory, antimalarial, antioxidant and hepatoprotective activities. A recent study has been documented that, kalmegh is having anti-HIV properties due to presence of important active constituent Andrographolide [1]. The therapeutic activities of the plant are attributed to andrographolide and diterpenides. The whole herb is the source of several diterpenoids of which andrographolide is important and is distributed all over the plant in different proportions. The leaves contain the maximum andrographolide (2.50%) compare to stem (2%) and capsule (0.15%) [2]. The use and marketing demand of herbal medicine is increasing for the safety and prevention concerns of human health. Commercial cultivation of medicinal plants with good agriculture practices is most important. In this concern to meet the demand of growing population with good quality of produce has been achieved through the good agriculture practices as well as good agriculture management. In this view, the investigation has been conducted to different plant geometry with optimize the nutrient supply through integrated use of organic and inorganic fertilizers for higher yield per unit area of kalmegh.

2. MATERIALS AND METHODS

2.1 Experimental Site

An investigation was conducted during*kharif* season of 2019-2020 atHorticulture Farm, Main Agricultural Research Station, College of Agriculture, University of Agricultural Sciences, Raichur, Karnataka, India which is situated in North Eastern Dry Zone (Zone-II) of Karnataka at 16^{o} 15' N latitude, 77^{o} 21' East longitudes at an altitude of 400 m above mean sea level. The soil of the experimental site was sandy clay loam in texture having high organic carbon, low available nitrogen, high available phosphorus and medium in exchangeable potassium with slightly alkaline in reaction.

2.2 Experimental Design and Details of Treatments

The experiment was laid out in Split plot design with 3 replications. There are 15 treatment combinations comprising of three main plots as different spacing*viz*., S_1= 30cm×15 cm, S_2 = 30cm×30 cm, S_3 = 30cm×45 cm and five subplots as different organic and inorganic fertilizer combinations*viz*., F_1 = 100% RDF (75:75:50 NPK kg ha^{-1}), F_2 = FYM alone equivalent to recommended N, F_3 = Vermicompost alone equivalent to recommended N, F_4 = 50% RDN + 50% FYM equivalent to recommended N and F_5= 50% RDN + 50% Vermicompost equivalent to recommended N.

2.3 Crop Measurements

Seeds were sown in nursery, before sowing the seeds were soaked in water for 12 hours than treated with Carbendazim (2g kg^{-1} of seeds) and 40 – 45 days old seedlings were used for transplanting. All the standard recommended cultivation practices were followed during the cultivation of kalmegh. Observation on growth parameters were recorded on five randomly selected plants in each replication of different treatments at 30, 60 and 90 days of transplanting (DAP). Harvesting of kalmegh was done at maturity (110 DAT).

2.4 Statistical Analysis

The data collected on different parameters during the course of investigation were subjected to Fisher's method of analysis of variance and interpretation of data was done as per the procedure described by Panse and Sukhatme [3]. The level of significance used in 'F' test was p= 0.05.

3. RESULTS AND DISCUSSION

Growth attributes of the kalmegh as influences by the geometry and integrated nutrient management are presented in the Table 1(a) and 1(b). The growth pattern was progressively increasing during all the growing stages with respect to all the growth parameters. The significantly taller plants (56.62 cm) and higher leaf area index (1.61) was observed in the narrow spacing with imposition of 50% RDN + 50% vermicompost equivalent to recommended N (S_1F_5) over S_1F_1. The taller plants were noticed under narrow spacing compare to wider spacing. The narrow spaced plants grown vertically than horizontal might be due to more competition for the radiation to rescue the photosynthetic demand of plant and these plants grow taller by using the basic resources such as water, sunlight and nutrients. The same results have been observed by Tansi et al., [4] in stevia. The higher leaf area index was observed in narrow spacing which might be due to the lesser ground area of the crop leading to the higher leaf area index where as more ground area of crop resulted in the lesser leaf area index [5].

The higher number of primary branches per plant (24.49), number of leaves per plant (150.78), leaf area (814.19cm^2) and dry matter accumulation (36.10 g $plant^{-1}$) was noticed with wider spaced plant with the consortia of application of 50% RDN + 50% vermicompost equivalent to recommended N (S_3F_5) over S_1F_1. This might be due the increases in the photosynthetic activity due to penetration of more sunlight on plant leads to vigorous growth of the herbage (Pal et al., 2019 in kalmegh). Application chemical fertilizer in combination with vermicompost resulted higher uptake of the nutrient (especially nitrogen) which enhances the cell multiplication, elongation and differentiation leads to increased plant growth which might be results in more number of branches and leaves per plant [6]. As number of leaves shown higher in wider spacing due to more light intensity, surface area, less competition for nutrients leads to higher leaf area also with the high chlorophyll content and leaf production which produced due to the application nitrogen application ultimately helps increasing the photosynthetic activity [7,8]. Dry matter accumulation was increased progressively with the advancement in plant age till the maturity found to be better translocation of carbohydrate and their utilization for the production of more number of leaves and number of branches reported by Divya et al. (2018) and Shivani et al. [9] in kalmegh.

The increment in the number of branches and number of leaves per plant resulted in the higher fresh and dry herbage yield (Table 2). Narrow spaced plants with application found to be higher 50% RDN + 50% vermicompost equivalent to recommended N (S_1F_5) noticed the significantly higher fresh and dry herbage yield per hectare (15.81 and 7.37 kg ha^{-1}) over S_3F_1. The concept of HDP followed through 30 x 15 cm which accommodated more number of plants per unit area would result in more fresh and dry herbage yield per unit area. Increased biomass also noticed by the integrated application of 50% RDN + 50% vermicompost equivalent to recommended N to supply the N usage of crop would increased the better growth parameters, herbage yield of good quality in kalmegh. The higher dry matter accumulation attributed due to the more number of leaves and branches per plant owing to availability of more nutrient continuously from organic and inorganic source of nutrient resulted in the increased fresh herbage yield which supported with the findings of Himanshu et al. [10] and Amala et al., [11] in kalmegh. Similar findings are noticed by Cheena et al. [12], Shwetha et al. [13], Shakywa et al. [14] and Sadbhawana et al. [15] in kalmegh.

Table 1(a). Influence of plant geometry and integrated nutrient management on growth attributes of kalmegh

Treatments	Plant height (cm)						Number of Primary Braches per plant						Number of leaves per plant					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
S_1	48.80	54.00	55.94	54.21	56.62	53.91	16.54	21.20	21.41	22.79	24.17	21.22	120.51	130.9	131.57	133.81	142.03	131.76
S_2	47.94	54.44	54.43	55.73	56.15	53.74	17.60	22.14	22.74	23.45	24.28	22.04	123.56	131.66	136.97	139.34	141.07	134.52
S_3	47.07	49.33	51.4	52.70	54.70	51.04	17.17	22.95	24.38	23.49	24.49	22.50	125.63	144.01	146.09	148.42	150.78	142.99
Mean	**47.94**	**52.59**	**53.92**	**54.21**	**55.82**		**17.10**	**22.1**	**22.84**	**23.24**	**24.31**		**123.23**	**135.52**	**138.21**	**140.52**	**144.63**	
	S.Em.±			**C.D. at 5%**			**S.Em.±**			**C.D. at 5%**			**S.Em.±**			**C.D. at 5%**		
Main plot (S)	0.51			2.00			0.18			0.71			1.00			3.93		
Subplot (F)	0.28			0.82			0.20			0.58			0.75			2.19		
F at same level of S	0.48			1.41			0.35			1.01			1.30			3.80		
S at same or different	3.34			11.72			1.79			5.7			7.68			25.70		

Table 1(b). Influence of plant geometry and integrated nutrient management on growth attributes of kalmegh

Treatments	Leaf area(cm^2)						Leaf area index						Dry matter accumulation (g $plant^{-1}$)					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
S_1	602.54	667.57	684.17	709.19	766.97	686.09	1.32	1.43	1.51	1.51	1.61	1.48	22.51	23.88	23.47	22.78	23.29	23.18
S_2	617.82	671.47	712.23	738.48	761.79	700.36	0.80	0.90	0.90	0.93	0.96	0.90	22.66	27.44	28.27	28.95	27.78	27.02
S_3	628.16	734.44	759.69	786.61	814.19	744.62	0.54	0.57	0.59	0.60	0.62	0.58	31.83	33.71	33.75	34.9	36.10	34.06
Mean	616.17	691.16	718.7	744.76	780.99		0.89	0.97	1.00	1.01	1.06		25.66	28.35	28.49	28.88	29.06	
	S.Em.±			**C.D. at 5%**			**S.Em.±**			**C.D. at 5%**			**S.Em.±**			**C.D. at 5%**		
Main plot (S)	5.24			20.57			0.02			0.09			0.78			3.06		
Subplot (F)	3.95			11.54			0.01			0.03			0.47			1.38		
F at same level of S	6.85			19.98			0.02			0.06			0.82			2.38		
S at same or different level of F	40.29			134.74			0.15			0.52			5.32			18.47		

Table 2. Influence of plant geometry and integrated nutrient management on yield of kalmegh

Treatments	Fresh herbage yield (t ha^{-1})						Dry herbage yield (t ha^{-1})					
	F_1	F_2	F_3	F_4	F_5	Mean	F_1	F_2	F_3	F_4	F_5	Mean
S_1	9.84	10.62	11.66	13.47	15.81	12.28	3.78	4.62	5.80	6.11	7.37	5.54
S_2	5.52	6.21	7.21	8.07	8.90	7.18	2.85	2.85	4.42	4.20	4.20	3.70
S_3	4.16	5.10	6.69	6.66	6.91	5.91	1.38	1.92	2.48	2.99	3.06	2.32
Mean	6.51	7.31	8.52	9.40	10.54		2.67	3.13	4.23	4.43	4.88	
	S.Em.±			**C.D. at 5%**			**S.Em.±**			**C.D. at 5%**		
Main plot (S)	0.32			1.28			0.08			0.31		
Subplot (F)	0.17			0.50			0.07			0.20		
F at same level of S	0.30			0.86			0.12			0.34		
S at same or different level of F	2.09			7.38			0.66			2.16		

4. CONCLUSION

Medicinal plants are boon of nature and demand for herbal extracts is progressively increasing in developing countries. Production and productivity of the crop can be increased by the adoption of standardized production practices. The adoption of spacing of 30 x 15 cm with the consortia of application 50% vermicompost and 50% recommended N resulted in the higher number of branches and number of leaves per plant resulted in the higher fresh and dry herbage yield potentially offers improved soil health or sustainability compared to inorganic fertilizers alone.

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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Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/120529