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Impact of Spacings and Different Sources of Organic Nutrients on Growth, Soil Chemical Properties and Economics of Chia (*Salvia hispanica* L.)

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ABSTRACT

Background: Chia (*Salvia hispanica* L.) is a widely used potential crops which has a huge demand in Indian market and is being grow in some parts of India. Since it is a newly introduced crop with higher nutritional value there is need to modify the crop environmental complex with agronomic techniques. So the current study was done on basis of different spacing and organic nutrients at Research Institute on Organic Farming, University of Agricultural Sciences, GKVK, Bangalore during two *Rabi* seasons 2020-2021 and 2021-2022.

Methods: The treatments include five different spacing [60 cm × 30 cm (S_1), 75 cm × 15 cm (S_2), 75 cm × 30 cm (S_3), 90 cm × 15 cm (S_4) and 90 cm × 30 cm (S_5)] and three organic nutrient levels applied based on nitrogen equivalent [60 kg N equivalent ha^{-1}(N_1), 80 kg N equivalent ha^{-1}(N_2) and 100 kg N equivalent ha^{-1}(N_3)] which were evaluated under factorial randomized complete block design.

Result: The results showed that the significantly more number of branches both primary and secondary $plant^{-1}$) at 30 and 60 Days After Sowing (DAS) and at harvest were 6, 21 and 28 respectively and higher dry matter partitioning to leaf (22.53 g), stem (71.52 g) and spike (76.83 g) were recorded in S5and was on par with S_3. Among nutrient levels N_3 recorded more number of branches during 30 and 60 DAS and harvest and higher partitioning of dry matter to different plant parts. S_2N_3 recorded higher cost of cultivation (₹ 69,663 ha^{-1}), but more gross returns (₹ 2,75,386 ha^{-1}), net returns (₹ 2,06,118 ha^{-1}) and B: C ratio (3.98) was reported with S_4N_3. It was revealed during the study that neither spacing nor nutrient levels have shown significant influence on soil chemical properties.

Key words: Chia, Economics, Growth, Partition of dry matter, Soil chemical properties.

INTRODUCTION

With a projected spike in food demand from 59 to102 per cent affordably meeting food and nutritional security is a great challenge. Biased technological development by focusing on few plant species, the Indian food security has become dependent only on fewcrops (Kulczynski *et al.,* 2019). The appropriate counter measure is “greater nutrient source per unit of resource input” by usage of potential crops. Potential crops/underutilized crops/ orphan crops/ neglected crops are the life support species, with promising nutritional utility for the present as well as future needs of human kind, but these crops receive low priority from farming community (Prathyusha *et al.,* 2019).

Chia (*Salvia hispanica* L.) is an annual herb and one amongst the potential crops whose cultivation was suppressed and remained unknown for subsequent centuries. It belongs to *lamiaceae* family and plays a key role in preventing several long-term diseases and so it is considered as “functional food”. It has wider scope in Indian market, as it is the raw material for many industries like nutraceuticals and pharmaceutical because of its functional component (Patel *et al.*, 2021). In recent years, cultivation of this crop was started in Karnataka due to its easy cultivation under scarce availability of resources and remunerative price with good buy back arrangements. Conventional farming methods deteriorate the health of soil and lower the productivity, quality and also causes environmental pollution. The farming systems like organic farming is sustainable, economically viable and ecologically sounds (Toor *et al.*, 2021). Nutrients are very

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important in enhancing the yield potential of crop. Both bulky and concentrated manures are sources of essential plant nutrients in organic farming for sustained crop yield by supplying the plant nutrients in easily available form through decomposition. As the crop is newly introduced in India, there is necessity to develop package of practices, with this objective the current study was conducted on organic cultivation of Chia.

MATERIALS AND METHODS

The current research trail was conducted during two *Rabi* seasons 2020-21 and 2021-22 at Research Institute on Organic Farming (RIOF), University of Agricultural Sciences (UAS), Gandhi Krishi Vignan Kendra (GKVK), Bangalore. The soil of the trial site was red sandy loam with slightly acidity (pH 6.0), electric conductivity (0.40 dS m^{-1}) and organic carbon (0.77 per cent). Seed bed was prepared by ploughing twice and after obtaining fine tilth the lay out was made based on factorial randomized complete block design with three replications, two factors and 15 treatment combinations. The two factors *i.e.*, Factor A - Five different spacing [60 cm × 30 cm (S_1), 75 cm × 15 cm (S_2), 75 cm × 30 cm (S_3), 90 cm × 15 cm (S_4) and 90 cm × 30 cm (S_5)] and Factor B- three nutrient levels applied based on nitrogen equivalent [60 kg N equivalent ha^{-1}(N_1), 80 kg N equivalent ha^{-1}(N2) and 100 kg N equivalent ha^{-1} (N_3)] applied based on nitrogen (N) equivalent. Farm yard Manure (FYM) @10 t ha^{-1} was applied 15 days priorly to sowing for all the treatments. Sowing the Chia crop (Local variety) was done with allocation of spacing as per the treatment in each plot. Nutrients were applied after analyzing the concentration of nutrients present in FYM and Vermicompost (VC). 75 per cent of N is supplied through FYM as basal and 25 per cent of N was supplemented through top dressing of VC at 30 DAS. In net plot crop was harvested, threshed and weighed separately after obtaining the maturity and yield was computed in hectare basis.

Nondestructive method of sampling was made from five selected and tagged plants. The total number of primary branches $plant^{-1}$ were counted at 30 DAS, whereas both primary and secondary branches were recorded at 60 DAS and at harvest and their average value was considered. Partitioning of the dry matter of five tagged plants at harvest were uprooted then stem, leaves and spike were separated and oven dried at 60°C**.** Dry weight of each part plant-1 was recorded and expressed as g $plant^{-1}$. Soil chemical parameters were obtained by drawing of representative soil samples at depth of 0-15 cm before sowing of crop and after harvest. The pH value was estimated using pH meter as per Jackson, (1973). The electrical conductivity measured with conductivity bridge and expressed as dS m^{-1} as per Jackson (1973). The organic carbon of soil was determined as per Jackson (1973). The data collected was statistically analysied by adopting Fishers method of analysis of variance (ANOVA) as outlined by Gomez and Gomez, (1984). Critical difference values were calculated whenever the F-test was significant at 5 per cent level.

Table 1: Growth attributes of Chia crop as influenced by spacing and organic nutrient levels (Pooled data of 2 years).

Treatment	Number of branches $plant^{-1}$									Partitioning of dry matter								
	30 DAS				60 DAS				At harvest				Leaf (g $plant^{-1}$)				Stem (g $plant^{-1}$)				Spike (g $plant^{-1}$)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
S_1	4.52	5.66	5.72	5.30	11.52	15.78	16.36	14.55	14.77	21.30	22.40	19.49	12.88	18.60	18.64	16.71	41.57	57.85	58.29	52.57	24.95	59.65	61.05	48.55
S_2	4.85	5.86	6.04	5.58	12.85	18.15	18.75	16.59	16.60	22.41	25.39	21.47	14.10	19.27	19.57	17.64	52.34	65.04	66.33	61.24	31.47	55.37	59.86	48.90
S_3	5.29	6.63	6.70	6.21	14.10	21.84	22.54	19.49	19.74	28.97	29.66	26.12	16.65	23.31	23.41	21.13	53.88	72.13	72.38	66.13	43.28	77.30	78.83	66.47
S_4	4.99	6.04	6.14	5.72	13.41	20.18	21.38	18.32	18.07	25.47	25.70	23.08	15.02	21.90	22.25	19.72	52.53	67.65	70.06	63.41	40.26	58.72	60.25	53.07
S_5	5.39	6.95	7.02	6.45	15.33	23.65	24.47	21.15	20.00	31.75	32.57	28.11	17.75	23.86	25.98	22.53	56.36	75.61	82.58	71.52	52.01	90.83	87.66	76.83
Mean	5.01	6.23	6.32		13.44	19.92	20.70		17.83	25.98	27.15		15.28	21.39	21.97		51.34	67.66	69.93		38.40	68.37	69.53	
	S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)	
Spacing (S)	0.18		0.53		0.70		2.04		0.77		2.22		0.67		1.95		2.03		5.89		3.42		10.05	
Nutrient level (N)	0.14		0.41		0.55		1.58		0.59		1.72		0.52		1.51		1.57		4.56		2.65		7.68	
Interaction (S×N)	0.32		NS		1.22		NS		1.33		NS		1.17		NS		3.52		NS		5.93		NS	

Note: S_1: 60 cm × 30 cm, S_2: 75 cm × 15 cm, S_3: 75 cm × 30 cm, S_4: 90 cm × 15 cm, S_5: 90 cm × 30 cm.
N_1: 60 kg N equivalent ha^{-1}, N_2: 80 kg N equivalent ha^{-1}, N_3: 100 kg N equivalent ha^{-1}, DAS= Days after sowing.

Economics was calculated with the prevailing costs during the experimentation period. The cost of components such as land preparation, cost incurred on inputs and labour charges at prevailing market price during crop production years of 2020-2021 and 2021-2022 were considered for calculation of cost of cultivation. The other components like Gross returns and Net returns (₹ ha^{-1}) and B:C ratio were calculated by using the following formulas.

Gross returns (₹ ha^{-1}) =

Market price (₹ kg^{-1}) × Seed yield (kg ha^{-1})

Net returns (₹ ha^{-1}) =

Gross returns (₹ ha^{-1}) - Cost of cultivation (ha^{-1})

$$\text{B:C ratio} = \frac{\text{Gross returns (₹ ha}^{-1}\text{)}}{\text{Cost of cultivation (₹ ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSION

Growth attributes

The data related to growth attributes of Chia (Table 1) shows that significantly higher number of branches $plant^{-1}$ at 30, 60 DAS and at harvest (6.45, 21.15 and 28.11, respectively) was recorded with S_5 which was on par with S3 and the lesser number of branches $plant^{-1}$ was reported with S_1. N_3 recorded significantly higher branches $plant^{-1}$ at 30, 60 DAS and at harvest (6.32, 20.70 and 27.15, respectively) and was on par with N_2, lesser number of branches chia $plant^{-1}$ was reported with N1.The interaction effect was found to be non-significant. Mounika *et al.* (2021) in basil crop reported that more number of primary and secondary branches $plant^{-1}$ were in wider row spacing than compared narrow spacing which might be because of more availability of resources from the atmosphere, soil rhizosphere and optimum space to grow horizontally in wide spacing. In *Occimum basilicum* significantly more yield attributes were reported with wider spacing and application of higher dose of FYM by Policepatil *et. al.* (2020). Higher growth and yield attributes of tomato were observed with combination of FYM and vermicompost, FYM @ 20 t ha^{-1} + vermicompost @ 10 t ha^{-1} than application of FYM @ 10 t ha^{-1} + vermicompost @ 5 t ha^{-1} and control reported by Bairagya *et al.* (2022) and Shiny *et al*. (2022). Manures like vermicompost might have releasenitrogen into soil nutrient pooland causes improvement of growth parameters of chia.

Spacing S5recorded significantly more dry matter partitioning to leaves, stem and spike (22.53 g, 71.52 g and 76.83 g) which was on par with S_3 and the lower with S_1. N3 significantly partitioned higher dry matter to chia leaves,stem and spike (21.97 g, 69.93 g and 69.53 g) which was on par with N_2 and the lower with N_1.Partitioning of dry matter to leaves was not significantly differed due to the interaction of factors at harvest. The results are in close agreement with the findings of Umilsingh, (2020) in chia crop, it was reported that wider spacing of 60 cm × 30 cm resulted in more growth attributes due to low competition for the available resources between the plant parts, more branching pattern and more inter and intra row spacing compared to closer spacing. Ramesh *et al.* (2017) reported that quinoa grown under wider spacing of 60 cm × 10 cm along with higher doses of FYM resulted in higher yield attributes than narrow spacings of 30 cm × 10 cm with low levels of FYM application. FYM and VC improves root proliferation and biomass resulting in higher uptake of nutrients from surrounding root zone and greater assimilation, production and partition of dry matter to all plant parts.

Soil chemical properties

The pooled data of two years onsoil chemical properties after harvest (Table 2) shows that spacing has not showed significant influence on soil chemical properties, however numerically higher soil pH, EC and OC was reported with S_5 (6.27, 0.61 dS m^{-1} and 0.81 per cent) and lower values was recorded with S_2. Nutrient levels had not significantly influence soil chemical parameters. Higher pH, EC and OC was recorded with N_3 (6.23,0.55 dS m^{-1} and 0.80 per cent) and lower pH was recorded with N_1.The results are in line with findings of Singh *et al.* (2021) and Islam *et al.* (2024) who reported that neither spacing nor application of organic manures had significant influence on soil chemical properties.

Table 2: Chemical properties of soil after harvest of Chia crop as influenced by spacing and organic nutrient levels (Pooled data of 2 years).

Treatment	Soil pH				Soil EC (ds m^{-1})				Soil OC (%)			
	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean	N_1	N_2	N_3	Mean
S_1	5.96	6.14	6.19	6.10	0.22	0.42	0.47	0.37	0.74	0.78	0.78	0.76
S_2	5.91	6.06	6.09	6.02	0.17	0.35	0.38	0.30	0.75	0.78	0.78	0.77
S_3	5.99	6.20	6.21	6.13	0.34	0.49	0.53	0.45	0.77	0.79	0.80	0.79
S_4	5.95	6.09	6.13	6.06	0.22	0.41	0.42	0.35	0.75	0.78	0.79	0.77
S_5	6.06	6.22	6.53	6.27	0.36	0.54	0.95	0.61	0.77	0.82	0.84	0.81
Mean	5.97	6.14	6.23		0.26	0.44	0.55		0.75	0.79	0.80	
	S. Em ±		CD (p=0.05)		S. Em ±		CD (p=0.05)		S.Em ±		CD (p=0.05)	
Spacing (S)	0.22		NS		0.09		NS		0.03		NS	
Nutrient level (N)	0.17		NS		0.07		NS		0.02		NS	
Interaction (S×N)	0.39		NS		0.15		NS		0.04		NS	

Note: S_1: 60 cm × 30 cm, S_2: 75 cm × 15 cm, S_3: 75 cm × 30 cm, S_4: 90 cm × 15 cm, S_5: 90 cm × 30 cm.

N_1: 60 kg N equivalent ha^{-1}, N_2: 80 kg N equivalent ha^{-1}, N_3: 100 kg N equivalent.

Table 3: Economics of chia crop based on different spacing and organic nutrients during two seasons (*Rabi* 2020-21 and 2021-22).

Treatment	Cost of cultivation (₹ ha^{-1})			Gross returns (₹ ha^{-1})			Net returns (₹ ha^{-1})			B: C ratio		
	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean	2020	2021	Mean
T_1 - S_1 N_1	52351	52281	52316	164998	156748	160873	112646	104467	108556	3.15	3.00	3.07
T_2 -S_1 N^2	60685	60615	60650	207299	196934	202117	146614	136319	141467	3.42	3.25	3.33
T_3 -S_1 N_3	69018	68948	68983	210385	199866	205125	141367	130917	136142	3.05	2.90	2.97
T_4 -S_2 N_1	53011	52981	52996	181517	172441	176979	128505	119459	123982	3.42	3.25	3.34
T_5 -S_2 N_2	61345	61315	61330	219225	208263	213744	157880	146948	152414	3.57	3.40	3.49
T_6-S_2 N_3	69678	69648	69663	222218	211107	216662	152539	141459	146999	3.19	3.03	3.11
T_7 -S_3 N_1	51861	51781	51821	162804	154663	158734	110942	102882	106912	3.14	2.99	3.06
T_8 -S_3 N_2	60195	60115	60155	199771	189783	194777	139577	129668	134622	3.32	3.16	3.24
T_9 -S_3 N_3	68528	68448	68488	200942	190895	195919	132414	122447	127430	2.93	2.79	2.86
T_{10} -S_4 N_1	52621	52581	52601	170551	162023	166287	117929	109442	113686	3.24	3.08	3.16
T_{11} -S_4 N_2	60955	60915	60935	223222	212061	217641	162267	151146	156706	3.66	3.48	3.57
T_{12} -S_4 N_3	69288	69248	69268	282448	268325	275386	213159	199077	206118	4.08	3.87	3.98
T_{13} -S_5 N_1	51766	51681	51724	146063	138760	142411	94296	87078	90687	2.82	2.68	2.75
T_{14} -S_5 N_2	60100	60015	60057	184385	175165	179775	124285	115151	119718	3.07	2.92	2.99
T_{15} -S_5 N_3	68433	68348	68391	190152	180645	185398	121719	112296	117008	2.78	2.64	2.71

Note: S_1: 60 cm × 30 cm, S_2: 75 cm × 15 cm, S_3: 75 cm × 30 cm, S_4: 90 cm × 15 cm, S_5: 90 cm × 30 cm N_1: 60 kg N equivalent ha^{-1}, N^2: 80 kg N equivalent ha^{-1}, N_3:100 kg N equivalent ha^{-1}, DAS= Days after sowing, MRP = Rs.200.

Economics

A new crop or a technology is accepted by the farming community based on the profits realized upon cost involved in production. Data pertaining to effect of spacing and organic nutrient levels on economics (Table 3) shows that more cost of cultivation (₹ 69,663 ha^{-1}) was recorded with S_2 N_3, whereas lesser cost of cultivation (₹ 51,724 ha^{-1}) was with S_5N_1. The higher gross and net returns (₹ 2,75,386, ₹ 2,06,118 ha^{-1}, respectively) and B: C ratio (3.98) was recorded with spacing of S_4N_3. The results are in close conformity with findings of Hebbal *et al.* (2018) who reported that 30 cm × 10 cm recorded higher cost of cultivation (₹ 33659), gross returns (₹ 110484) and net returns (₹ 76825) than wider spacing of 45 cm × 30 cm and 30 cm × 30 cm. Similarly, higher gross and net returns of ₹ 108242 and ₹ 78326, respectively were recorded with application of higher dose of FYM 7.5 t ha^{-1} than lower doses and was in line with findings of Ramamoorthy *et al.* (2021).

CONCLUSION

Growth attributes of chia differed significantly by the influenceof different crop geometries and nutrient levels. Wider spacing of 90 cm × 30 cm has significantly higher growth attributes and the on-par results were recorded with 75 cm × 30 cm spacing than other spacings. 100 kg N equivalent ha^{-1} application recorded significantly growth attributes and wason par with 80 kg N equivalent ha^{-1}. Spacing has no significant influence on soil chemical properties. Lesser cost of cultivation (₹ 60,935 ha^{-1}) was recorded with 80 kg N equivalent ha^{-1} but higher gross returns (₹ 2,75,386 ha^{-1}), net returns (₹ 2,06,118 ha^{-1}) and B: C ratio (3.98) was observed with 90 cm × 15 cm with 100 kg N equivalent ha^{-1}. So it can be conclude that wider spacing along with application 80 kg N equivalent ha^{-1} can be suggested for profitable chia cultivation.

Disclaimers

The views and conclusions in this article are manly those of the authors and do not represent the views of their affiliated institutions. The authors are responsible for the accuracy, completeness of the information and data provided. There is no acceptancy of any liability for direct or indirect losses resulting from the use of this content.

Conflict of interest

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