Environment and Ecology 40 (4B) : 2380—2385, October—December 2022
ISSN 0970-0420

Accessing Nitrogen Levels and Spacing on Yield and Economics of Chia (*Salvia hispanica* L.)

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Received 11 July 2022, Accepted 24 September 2022, Published on 10 November 2022

ABSTRACT

A field experiment was conducted during *kharif*, 2020 at experimental field of Krishi Vigyan Kendra (KVK)- National Rice Research Institute (NRRI), Cuttack to determine the "Accessing Nitrogen Levels and spacing on Yield and Economics of Chia (*Salvia hispanica* L.)". Agronomic management practices are one among the influential aspects for the success of any crop with efficient use of all the resources. Nitrogen is the prime yield-inhibiting mineral nutrient and major part of plant nutrition in agricultural ecosystems and crop production. As Chia being a new crop to East coast plain and hill region of odisha, various aspects of spatial arrangement besides nutrient requirement of this crop are to be investigated to harness potential yield of this crop. The experiment consisted of four, doses of nitrogen (40, 60, 80, 100 kg ha^{-1}) and two spacing (50 cm × 20 cm, 60 cm ×20 cm). The experiment was arranged in a statistical design of Randomized Block Design (RBD) with three replications. The present investigation indicates that, among different nitrogen levels the application of 100 kg N ha^{-1} at 50 cm × 20 cm spacing produced significantly superior plant height (151.48 cm), CGR (70.1 g/m^2 day^{-1}) and seed yield (1210 kg ha^{-1}). The highest seed yield produced by the application of 100 kg N ha^{-1} at 50 cm × 20 cm spacing is 49.58 % more than control plot (60 kg N ha^{-1} at 60 cm × 30 cm spacing). However, the application of 100 kg N ha^{-1} at 60 cm × 20 cm was found to be significantly effective in producing maximum number of leaves/plant (603.20), Dry weight (159 g/plant), Number of spikes/plant (91.07), Spike length (21.83 cm) and Haulm yield (6146.67 kg ha^{-1}). Treatment combination receiving 100 kg N ha^{-1} with 50 cm × 20 cm spacing fetched highest gross return (193600 ` ha$^{-1}$), net return (138008 ` ha^{-1}) and benefit cost ratio (2.48). The maximum net return obtained with application of 100 kg N ha^{-1} at closure spacing (50 cm × 20 cm) brought about 30 % more return than control (60-40-50 kg N-P-K ha^{-1} at 60 cm ×30 cm spacing).

Keywords Chia, Nitrogen levels, Spacing, Yield.

INTRODUCTION

The Chia (*Salvia hispanica* L.) is an herbaceous plant in the family Lamiaceae and native to mountain areas

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Fig. 1. Chia crop at flowering stage.

of Mexico and Guatemala Ixtaina *et al*. (2008). The crop can grow up to 1.5 meter height and the main edible part is seed Karim *et al*. (2015). Chia produces white or purple flowers and opposite arranged leaves has been shown in Fig. 1. Chia seeds can be a food supplement and are widespread in vegetarian and gluten-free diets. Chia is a plant characterized by low water requirement and well adapted to arid and semi-arid regions (Ayerza 1995). The flour, a by-product of oil extraction, can be used as human and animal feed supplement is high in fiber and constituents with antioxidant activity (Ayerza and Coates 1996).

Efficient fertilization is necessary in both economic and environmental terms. This minimizes nutrient losses to the environment while producing optimum crop yields. The quantities required of nutrients, for every crop and every soil in particular, must be respected. Nitrogen fertilizer is important for chia because it is high in protein content. Chia seed yields generally increase with an increasing nitrogen rate. Nitrogen is thus universally limiting factor in soil and most important for crops growth and yield, its management in the field level is necessary to obtain high seed yield. When a new species is introduced in a region, studies must be carried out to indicate if it will be adapted to the local conditions. In this context, the growth analysis can be used to evaluate the ecological adaptation of plants to new environments and the effects of agronomic management systems. In India, the cultivation of chia is still not very expressive and there is a lack of information regarding the growth, phenology, nutritional requirements and management strategies for a better use of the edaphoclimatic characteristics of each region.

Chia is a new crop for India so there is a lack of practical experiences on its cultivation and agronomy. At present not much information is available on the cultivation and agronomic requirements of Chia viz., plant population, planting geometry, fertilizer doses, irrigation requirement. Considering the increasing international demand of Chia, the information on agronomic management and the importance of nitrogen fertilization of crops in Alfisols of Odisha in India is meagre which an incentive to this work. Hence the present study was investigated with an objective to evaluate the response of planting geometry and nitrogen fertilization for the growth, development and productivity of chia.

MATERIALS AND METHODS

A field experiment was conducted during rainy (*kharif*) season of 2020, at the experimental area of the Krishi Vigyan Kendra (KVK)-National Rice Research Institute (NRRI), Cuttack, situated at 20.5º North Latitude and 80º East Longitude, with an average height of 23.5 m above the mean sea level. The average annual rainfall of the zone was 1577 mm received in 66 rainy days. The other distinct climatic features of experimental site has tropical climate, characterized by high temperature and humidity, medium to high rainfall and short and mild winters. The data on precipitation, temperature and relative humidity during the period of conducting the experiments were collected from the meteorological division of KVK. The soil chemical analysis revealed that soil was sandy loam in texture, acidic in reaction (*pH* 5.84) medium in organic carbon (0.54%), medium in available nitrogen (208.76 kg ha^{-1}) potassium (166.88 kg ha^{-1}), high in available phosphorus (77.40 kg ha^{-1}). The electrical conductivity of the soil was 0.45 dS m^{-1}.

The seeds of chia were used as the planting material laid out in Randomized Block Design (RBD). The experiment was conducted, having four, nitrogen management practices (40, 60, 80, 100 kg ha^{-1}) and two spacing (50 cm × 20 cm, 60 cm × 20 cm). There were nine treatments replicated thrice. Nine treatments combinations, comprising (T_1) 40 kg N ha^{-1} at 50 cm × 20 cm spacing (T_2) 60 kg N ha^{-1} at 50 cm × 20 cm spacing (T_3) 80 kg N ha^{-1} at 50 cm × 20 cm spacing (T_4) 100 kg N ha^{-1} at 50 cm × 20 cm spacing (T_5) 40 kg N ha^{-1} at 60 cm × 20 cm spacing (T_6) 60 kg N ha^{-1} at 60 cm × 20 cm spacing (T_7) 80 kg N ha^{-1} at 60 cm × 20 cm spacing (T_8) 100 kg N ha^{-1} at 60 cm × 20 cm spacing (T_9) 60 kg N ha^{-1} at 60 cm × 30 cm spacing.

The tillage operations were subjected to deep ploughing followed by two harrowing. The field levelling was accompanied with pre-sowing weeding. Crop was planted on second fortnight of July and harvested on first fortnight of November. Variety 'CHIAmpion W-83' was seeded manually. Three seeds were sown in each hill, and the optimum plant population was maintained by thinning out and gap filling operation has been shown in Figs. 2 and 3. The crop geometry was maintained as per the spacing prescribed for the particular treatments. The N was applied as specified by the treatments while the P and K fertilizers were applied at 40 and 50 kg ha^{-1} in all the treatments. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash respectively. Phosphorus and potassium were applied uniformly as basal to all the plots. Half dose of nitrogen was applied as basal and remaining half dose applied 45 days after sowing. Hand weeding was done when they appeared; no pests or diseases were observed. The crop plants of net plot area were harvested plot wise. The crop was

Fig. 2. Crop at two leaves stage.

Fig. 3. Plot after maintaining plant population (After Thinning and Gap filling operation).

spread on cemented floor for sun drying and grain was separated by stick hammering the inflorescence portion. Biometrical observation on plant height, number of leaves and growth analysis were taken from the standing crop in the experiment. Five plants were selected randomly and tagged in each net plot for recording observations on growth parameters at 20, 40, 60, 80 and 100 days after sowing and on yield attributing characters at harvest. The data were statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Growth parameter

Crop growth and development in the Chia was measured in terms of plant height (cm), No. of leaves/plant, Dry matter accumulation (g/plant) and Crop growth rate (CGR, $g/m^2/day$) at harvest are recorded and tabulated in Table 1. The application of 100 kg N ha^{-1} at 50 cm × 20 (T_4) cm spacing produced significantly higher plant height (151.48 cm). This is due to application of more nitrogen, which increased

Table 1. Effect of Nitrogen levels and different row spacing on growth of Chia.

Treatment	Treatment combination	Plant height (cm)	Number of leaves/ Plant	Dry weight (g/plant)	CGR ($g/m^2/day$) 60-80 DAS	Number of spikes/ plants	Spike length (cm)	Test Weight (g)
T_1	40 kg N ha^{-1} at 50 cm × 20 cm spacing	104.89	321.53	111.46	50.74	33.20	11.32	1.02
T_2	60 kg N ha^{-1} at 50 cm × 20 cm spacing	132.01	420.40	132.26	59.87	51.93	13.65	1.07
T_3	80 kg N ha^{-1} at 50 cm × 20 cm spacing	142.41	487.73	144.89	65.58	56.80	14.27	1.13
T_4	100 kg N ha^{-1} at 50 cm × 20 cm spacing	151.48	595.40	156.19	70.10	86.47	20.03	1.17
T_5	40 kg N ha^{-1} at 60 cm × 20 cm spacing	95.51	370.00	119.96	45.19	41.73	11.72	1.04
T_6	60 kg N ha^{-1} at 60 cm × 20 cm spacing	127.55	436.53	140.71	53.21	54.47	13.69	1.09
T_7	80 kg N ha^{-1} at 60 cm × 20 cm spacing	138.12	540.27	146.79	55.30	65.20	16.47	1.14
T_8	100 kg N ha^{-1} at 60 cm × 20 cm spacing	148.32	603.20	159.43	58.99	91.07	21.83	1.18
T_9	60 kg N ha^{-1} at 60 cm × 30 cm spacing	119.41	565.40	148.26	37.05	74.40	17.93	1.10
	SEm (±)	0.65	4.52	4.55	1.77	1.38	0.61	0.01
	CD (P=0.05)	1.95	13.55	13.63	5.30	4.14	1.82	0.03

the nitrogen content of the cell sap in the form of protein, amides and aminoacids which resulted in the cell elongation and multiplication which ultimately increased the plant height. This result was in accordance with the data recorded by Inamullah *et al*. (2012). Under high plant density area, plants were competing more for light, this has led to suppression of lateral growth and increased apical dominance. These results are in accordance with the findings of Mary *et al*. (2018). The increase in plant height at higher plant density is probably caused through stem elongation and increase of number of nodes per plant due to mutual shading.

The highest number of leaves (603.20) was observed with application of 100 kg N ha^{-1} at 60 cm × 20 cm spacing (T_8) was significantly superior to other treatment combinations except statistically on par with 100 kg N ha^{-1} at 50 cm × 20 cm (T_4). Further, nitrogen might have increased the chlorophyll content of leaves and resulted in increased synthesis of carbohydrates, which led to new cells formation and thus increased the number of leaves. It was observed that the higher number of leaves was gained in the wider intra row spacing accompanied by higher levels of nitrogenous fertilizer. These results are in conformity with the findings of Shehu *et al*. (2010).

The dry matter production was significantly influenced by application of 100 kg N ha^{-1} at 60 cm × 20 cm (159.43 g; T_8). The treatment combination 100 kg N ha^{-1} at 50 cm × 20 cm spacing (T_4) were statistically at par with 100 kg N ha^{-1} at 60 cm × 20 cm spacing (T_8). Crop growth rate (CGR) was significantly found maximum (70.10 $g/m^2/day$) with 100 kg N ha^{-1} at 50 cm × 20 cm spacing (T_4) which was followed by 80 kg N ha^{-1} at 50 cm × 20 cm spacing (T_3). This might be due to the fact that fertilizer induces the growth of the plant through active protein metabolism, transportation of photosynthates and synthesis of nucleic acid and proteins. Hence during the vegetative stage, nitrogen nutrition of the plant to a large extent controls the growth of plant. As plant density increases, the number of spikes per plant decreases. These results are in conformity with the findings of Mary *et al*. (2018).

Yield attributes

Number of spikes/plants, spikes length (cm) and test weight (g) was recorded, analyzed and presented in Table 1. The significantly maximum number of spikes/plants, higher spikes length (cm) and test weight (g) was 70.24, 21.83 and 1.18 g, respectively obtained with highest level of nitrogen (100 kg N ha^{-1}) accompanied by wider spacing (60 cm × 20 cm) (T_8). While 100 kg N ha^{-1} at 50 cm × 20 cm spacing (T_4) was found to be at par with 100 kg N ha^{-1} at 60 cm × 20 cm spacing (T_8) in spikes length (cm) and test weight (g) observation. These results are in line with the findings of Mary *et al*. (2018) and Maruti *et al*. (2018).

Yield

The different row spacing with levels of nitrogenous

Table 2. Effect of Nitrogen levels and different row spacing on yield attributes of Chia.

Treatments	Treatment details	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	Cost of cultivation (INR ha^{-1})	Gross return (INR ha^{-1})	Net return (INR ha^{-1})	B:C
T_1	40 kg N ha^{-1} at 50 cm × 20 cm spacing	496.67	2640.00	16.10	53637.00	79360.00	25723.00	0.48
T_2	60 kg N ha^{-1} at 50 cm × 20 cm spacing	820.00	4220.00	16.29	53952.00	131200.00	77248.00	1.43
T_3	80 kg N ha^{-1} at 50 cm × 20 cm spacing	983.33	5836.67	14.42	54775.00	157332.00	102557.00	1.87
T_4	100 kg N ha^{-1} at 50 cm × 20 cm spacing	1210.00	5918.00	16.99	55592.00	193600.00	138008.00	2.48
T_5	40 kg N ha^{-1} at 60 cm × 20 cm spacing	363.33	2176.67	14.29	53607.00	58132.00	4525.00	0.08
T_6	60 kg N ha^{-1} at 60 cm × 20 cm spacing	756.67	3703.33	16.97	53922.00	121067.00	67145.00	1.25
T_7	80 kg N ha^{-1} at 60 cm × 20 cm spacing	916.67	4903.33	15.76	54745.00	146667.00	91922.00	1.68
T_8	100 kg N ha^{-1} at 60 cm × 20 cm spacing	1133.33	6146.67	15.57	55562.00	181332.00	125770.00	2.26
T_9	60 kg N ha^{-1} at 60 cm × 30 cm spacing	600.00	3536.67	14.52	53900.00	96000.00	42100.00	0.78
	SEm (±)	32.85	166.94	1.01	-	-	-	-
	CD (P=0.05)	98.49	500.48	-	-	-	-	-

fertilizer show significant result influenced among different treatments (Table 2). Seed yield (kg ha^{-1}), haulm yield (kg ha^{-1}) and harvest index (HI %) was evaluated and analyzed that application of 100 kg N ha^{-1} with narrow spacing (50 cm × 20 cm; T_3) brought about higher yield of 1210.00 kg ha^{-1} than application of 100 kg N ha^{-1} wider spacing (60 cm × 20 cm) which followed similar trend and contributed 49.58% more yield compared to the lowest yield receiving treatment 40 kg N ha^{-1} at 50 cm × 20 cm spacing (T_1). The treatment combination 100 kg N ha^{-1} at 60 cm × 20 cm spacing had computed maximum haulm yield (6146.67 kg ha^{-1}) was statistically at par with 100 kg N ha^{-1} at 50 cm × 20 cm spacing (T_4) and 80 kg N ha^{-1} at 50 cm × 20 cm spacing (T_3).

Economics

Data related to economics was computed from yield obtained and market price of produced showed in Table 2. From data, maximum gross retun (`193600.00), net return (`138008.00) and harvest index (HI %) were observed with 100 kg N ha^{-1} at 50 cm × 20 cm spacing (T_4). The treatment combination (T_4)100 kg N ha^{-1} at 50 cm × 20 cm spacing had computed maximum B:C (2.48) followed by (T_8)100 kg N ha^{-1} at 60 cm × 20 cm spacing having B:C (2.26).

CONCLUSION

Optimum seed yield of chia was recorded at 100 kg N ha^{-1} at spacing of 50 cm × 20 cm. Comparing the seed yield of chia the application of 100 kg N ha^{-1} along with 50 cm row spacing had improved the seed yield of chia by 49.58 % compared to the lowest yield recorded treatment. The profitability of the study showed that application of 100 kg N ha^{-1} with a row spacing of 50 cm provide the relatively highest net return.

ACKNOWLEDGMENT

Conceptualization and designing of the research work (P. Mohanty and Umesha C.), Execution of field/lab experiments and data collection (P. Mohanty and DR Sarangi), Analysis of data and interpretation (P. Mohanty, DR Sarangi, Umesha C. and M. R. Meshram), Preparation of manuscript (P. Mohanty and M. R. Meshram).

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