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Effect of Different Spacings and Fertilizer Levels on Growth Parameters and Yield of Chia (*Salvia hispanica* L.)

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ABSTRACT

A field experiment was conducted in Kharif 2016 at the research field of College of Agriculture, Shivamogga to determine the effect of different spacings and fertilizer levels on the growth parameters and yield of Chia crop. Experiment consisted of three levels of spacings (S_1: 60cm x 22.5cm, S_2: 60cm x 30cm, S_3: 60cm x 45cm) and three levels of fertilizers (F_1: 30:20:25 kg NPK ha^{-1}, F_2: 60:40:50 kg NPK ha^{-1}, F_3: 90:60:75 kg NPK ha^{-1}). Experimental design adopted was two factor symmetrical experiment with RCBD having three replications. Crop was first established in nursery and then transplanted in main field at 18 days after sowing. A full dose of phosphorus and potassium were applied as basal while 50 per cent of nitrogen was applied as basal and remaining half, 20 days after basal dose as top dressing. Results of the study had shown an increase in the yield level at a spacing of $S_{3:}$ 60cm x 45cm (597.59 kg ha^{-1}) and a fertilizer level of F_3: 90:60:75 kg NPK ha^{-1} (623.60 kg ha^{-1}). Significantly higher seed yield (676.58 kg ha^{-1}) was obtained in the treatment combination S_3F_3- 60cm x 45 cm with 90: 60: 75 kg NPK ha^{-1}. Results also revealed that growth parameters viz., number of branches (20.67), leaves (202.50), leaf area (8388.00 cm^2) and total dry matter (168.35 g $plant^{-1}$) were increased at a spacing of 60 cm x 45 cm and fertilizer level of 90:60:75 kg NPK ha^{-1} compared to other treatments.

Key words: *Chia, spacing, fertilizer levels, growth parameters*

INTRODUCTION

Malnutrition problem in the world is a big threat that has been facing by the humanity and there is a need to adopt nutritionally secured new diet practices for better health of population. Malnourishment problem can be avoided by going in for cultivation and consumption of new super food crops which are rich in protein, Omega-3 fatty acids, minerals, vitamins and dietary fibre. Among these, the most important super food crop is *Salvia hispanica* L., commonly referred as Chia. Chia seeds are source of Omega-3 fatty acid (α-linolenic acid), soluble and insoluble fibres and proteins in addition to other important nutritional components, such as vitamins, minerals and natural antioxidants.

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Chia (*Salvia hispanica* L.) is an annual crop belonging to the family Lamiaceae originated in Mexico and Guatemala[5]. Chia can grow up to one metre tall and has leaves arranged in opposite direction. It produces white or purple flowers with 3-4 mm size having small corollas and fused flower parts. The seed colour varies from black, grey and black spotted to white and the shape is oval with size ranging from one to two mm[3]. However, commercialized Chia is mainly black spotted, followed by a low but higher percentage of white seeds[1].Agronomic management is one of the most important aspects for the success of any crop with efficient use of all the resources. Studies on agronomic management of Chia crop are limited as it is a newly introduced crop to India in general and Karnataka in particular. For a farmer to get maximum profit from any crop, study about its growth and responses towards inputs is very much essential. As Chia being a new crop, different aspects of plant population and spatial arrangement besides nutrient requirement of this crop are to be studied to harness potential yield of this crop. Standardisation of suitable location specific agronomic practices with respect to spacing and fertilizer application is essentially required to popularize this crop in Southern Transition Zone of Karnataka.

MATERIAL AND METHODS

A field experiment was conducted during *Kharif* season of 2016 at experimental field of College of Agriculture, Navile, Shivamogga. The crop variety used in the experiment was CHIAmpion B-1. Experimental site was situated at $14^0\ 0^1$ to $14^0\ 1^1$ North Latitude and $75^0\ 40^1$to $75^0\ 42^1$ East Longitude with an altitude of 650 meters above the mean sea level. The average rainfall of the zone was 817 mm received in 56 rainy days. Soil of the experimental site belonged to taxonomic class sandy loam texture. The experiment was laid out in factorial Randomized Complete Block design with nine treatment combinations and three replications. The treatments consist of three spacings (S) – S_1: 60cm x 22.5cm, S_2: 60cm x 30cm and S_3: 60cm x 45cm and three fertilizer levels (F) – F_1: 30:20:25 kg NPK ha^{-1}, F_2: 60:40:50 kg NPK ha^{-1} and F_3: 90:60:75 kg NPK ha^{-1}. The Chia crop was first established in nursery and then transplanted to main field at eighteen days after sowing. Full dose of phosphorus and potassium were applied as basal during transplanting while, fifty per cent of nitrogen was applied as basal and remaining half was top dressed at 20 DAT. Five plants were selected at random and labelled in each net plot for recording observations on growth and yield parameters at 30 DAT, 60 DAT, 90 DAT and at harvest. Further, statistical analysis of the data was carried out as per the method suggested by[4].

EXPERIMENTAL RESULTS AND DISCUSSION

Effect of different spacings and fertilizer levels on growth parameters of Chia crop

The data on growth parameters of Chia as influenced by different spacings and fertilizer levels are presented in Table 1 and 2. The spacing of 60 cm x 22.5 cm resulted in significantly higher plant height (100.19 cm) at harvest stage compared to other intra row spacings (94.32 cm – 99.77 cm). The plant height slightly increased due to increase in plant density. Under high plant density situations, plants were competing more for light, this has led to suppression of lateral growth and increased apical dominance. Significant increase in plant height right from early stage of crop growth under closer spacing seems to be due to mutual shading because of dense population which might have decreased the availability of light to the plants. Application of fertilizer level 90:60:75 kg NPK ha^{-1} produced significantly higher plant height (106.35 cm) compared to other fertilizer levels (86.08 cm – 101.85 cm). Significantly maximum plant height was obtained with interaction of closer intra row spacing with highest fertilizer application (112.47 cm) and lowest plant height was obtained with closer intra row spacing with less fertilizer dosage (80.78 cm), was on par with S_3F_1 (60 cm x 45 cm with 30:20:25 kg NPK ha^{-1}) interaction (85.53 cm). The results revealed the importance of nitrogen on plant growth. The positive influence of nitrogen on plant height was due to the fact that nitrogen is required for cell division and cell elongation which triggers the growth of meristematic tissue and the efficient utilization of this by the plants manifested in production of taller plants[6].Significant differences in growth parameters were noticed at different spacings and fertilizer levels. Statistically superior values were obtained at spacing 60 cm x 45 cm for number of branches at harvest (19.53), number of leaves at 90 days after transplanting (DAT) (179.82), leaf area at 90 DAT (7472.44 cm^2) and total dry matter accumulation at 90 DAT (154.22 g $plant^{-1}$) compared to other intra row spacings. At closer inter plant spacing, lower number of branches, leaves $plant^{-1}$, leaf area and total dry matter accumulation were recorded, due to reduction in lateral growth, increased inter nodal distance and also due to increased competition between plants for space, moisture, light and nutrients. These results are in conformity with the findings of Yeboah *et al*[7]. The fertilizer level of 90:60:75 kg NPK ha^{-1} resulted significantly higher number of branches $plant^{-1}$ (18.42), leaves $plant^{-1}$ (163.04), leaf area (6825.11 cm^2) and total dry matter accumulation (140.66 g $plant^{-1}$) as compared to other fertilizer levels. Similar trend was noticed with respect to number of branches and number of leaves these were increased with increase in fertilizer dose. Such an increase in the number of leaves may be further related to increase in the uptake of nutrients particularly nitrogen which is a constituent of protein and component of protoplasm. 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. Chia crop partially defoliating the leaves during the time of maturity but, due to increase in nitrogen application at higher fertilizer level, persistence of leaves was more in the treatments received higher fertilizer application. Interaction at spacing of 60 cm x 45 cm and fertilizer level of 90:60:75 kg NPK ha^{-1} had produced significantly superior values for number of branches $plant^{-1}$ (20.67), leaves $plant^{-1}$ (202.50), leaf area (8388.00 cm^2) and total dry matter accumulation (168.35 g $plant^{-1}$) as compared to other treatment combinations. Significantly higher leaf area index at 90 DAT (3.59) and leaf area duration (97.98 days) between 60 – 90 DAT was resulted at intra row spacing 60 cm x 22.5 cm compared to other spacings. Fertilizer level of 90:60:75 kg NPK ha^{-1} recorded significantly superior leaf area index (3.61) and leaf area duration (99.81 days) compared to other levels. Among different interactions, significantly higher leaf area index (3.97) and leaf area duration (113.29 days) was resulted at a spacing of 60 cm x 22.5 cm with fertilizer level 90:60:75 kg NPK ha^{-1}. The decrease in LAI and LAD at wider inter plant spacing was related to higher land area occupied by each plant. On the contrary, increase in spacing significantly increased the photosynthesizing surface area. This result was supported by the findings of Bilalis *et al.*[2] who reported higher LAI at closer spacing compared to wider spacing. Leaf area index and leaf area duration increased at higher fertilizer level may be attributed to the production of more number of branches and leaves which may be due to uptake of more nitrogen, phosphorus and potassium and efficient production of photosynthates and its utilisation.

Effect of different spacings and fertilizer levels on yield of Chia

The data on seed yield of Chia crop as influenced by different spacings and fertilizer levels is presented in Table 2. Crop planted at a spacing of 60cm x 45cm spacing resulted in maximum seed yield (597.59 kg ha^{-1}) was on par with spacing 60cm x 30cm (580.69 kg ha^{-1}) and significantly superior to spacing 60cm x 22.5cm (489.15 kg ha^{-1}). Similar results have been reported by Yeboah *et al.*[7] that 0.5mx0.5m (40,000 plants ha^{-1}) planting density produced the highest biomass and seed yield in both years of study (2012 & 2013). Crop maintained at fertilizer level 90:60:75 kg NPK ha^{-1} resulted into significantly superior yield (623.60 kg ha^{-1}) as compared to other fertilizer levels (477.95- 565.88 kg ha^{-1}). The treatment combination of 60cm x 45cm spacing and fertilizer level of 90:60:75 kg NPK ha^{-1} (S_3F_3) produced significantly highest yield (676.58 kg ha^{-1}) and was superior to all other treatment combinations (357.58- 582.75 kg ha^{-1}). The variation in yield was associated with variation in plant population and number of spikes produced as well as difference in the amount of nutrients available in the rhizosphere of plant system.

Table 1: Plant height, number of branches, number of leaves and leaf area as influenced by different spacings and fertilizer levels

Treatments	Plant height (cm)	Number of branches	Number of leaves	Leaf area (cm^2)
Spacing (S)				
S_1: 60 cm x 22.5 cm	100.19	15.12	113.83	4840.78
S_2: 60 cm x 30 cm	99.77	17.02	145.82	6277.78
S_3: 60 cm x 45 cm	94.32	19.53	179.82	7472.44
SEm±	**1.67**	**0.31**	**2.47**	**105.08**
CD (P= 0.05)	**5.00**	**0.93**	**7.41**	**315.02**
Fertilizer level (F)				
F_1: 30:20:25 kg NPK ha^{-1}	86.08	16.03	129.56	5575.22
F_2: 60:40:50 kg NPK ha^{-1}	101.85	17.22	146.87	6190.67
F_3: 90:60:75 kg NPK ha^{-1}	106.35	18.42	163.04	6825.11
SEm±	**1.67**	**0.31**	**2.47**	**105.08**
CD (P= 0.05)	**5.00**	**0.93**	**7.41**	**315.02**
Interaction (S x F)				
S_1F_1: 60 cm x 22.5 cm with 30:20:25 kg NPK ha^{-1}	80.78	13.22	95.33	4053.67
S_1F_2: 60 cm x 22.5 cm with 60:40:50 kg NPK ha^{-1}	107.33	14.89	121.17	5106.67
S_1F_3: 60 cm x 22.5 cm with 90:60:75 kg NPK ha^{-1}	112.47	17.26	125.00	5362.00
S_2F_1: 60 cm x 30 cm with 30:20:25 kg NPK ha^{-1}	91.93	16.83	127.33	5708.00
S_2F_2: 60 cm x 30 cm with 60:40:50 kg NPK ha^{-1}	101.54	16.89	148.50	6400.00
S_2F_3: 60 cm x 30 cm with 90:60:75 kg NPK ha^{-1}	105.83	17.33	161.63	6725.33
S_3F_1: 60 cm x 45 cm with 30:20:25 kg NPK ha^{-1}	85.53	18.03	166.00	6964.00
S_3F_2: 60 cm x 45 cm with 60:40:50 kg NPK ha^{-1}	96.68	19.89	170.95	7065.33
S_3F_3: 60 cm x 45 cm with 90:60:75 kg NPK ha^{-1}	100.74	20.67	202.50	8388.00
SEm±	**2.89**	**0.54**	**4.28**	**182.00**
CD (P= 0.05)	**8.67**	**1.61**	**12.84**	**545.62**

Table 2: Leaf area index, Leaf area duration, total dry matter accumulation and seed yield as influenced by different spacings and fertilizer levels

Treatments	Leaf area index	Leaf area duration (days)	Total dry matter accumulation (g $plant^{-1}$)	Seed yield (kg ha^{-1})
Spacing (S)				
S_1: 60 cm x 22.5 cm	3.59	97.98	108.37	489.15
S_2: 60 cm x 30 cm	3.49	96.87	128.04	580.69
S_3: 60 cm x 45 cm	2.77	77.30	154.22	597.59
SEm±	**0.06**	**1.61**	**2.20**	**9.62**
CD (P= 0.05)	**0.16**	**4.81**	**6.61**	**28.83**
Fertilizer level (F)				
F_1: 30:20:25 kg NPK ha^{-1}	2.92	80.70	121.07	477.95
F_2: 60:40:50 kg NPK ha^{-1}	3.32	91.63	128.90	565.88
F_3: 90:60:75 kg NPK ha^{-1}	3.61	99.81	140.66	623.60
SEm±	**0.06**	**1.61**	**2.20**	**9.62**
CD (P= 0.05)	**0.16**	**4.81**	**6.61**	**28.83**
Interaction (S x F)				
S_1F_1: 60 cm x 22.5 cm with 30:20:25 kg NPK ha^{-1}	3.00	78.92	101.51	357.58
S_1F_2: 60 cm x 22.5 cm with 60:40:50 kg NPK ha^{-1}	3.78	101.72	108.13	520.23
S_1F_3: 60 cm x 22.5 cm with 90:60:75 kg NPK ha^{-1}	3.97	113.29	115.47	589.63
S_2F_1: 60 cm x 30 cm with 30:20:25 kg NPK ha^{-1}	3.17	89.61	119.33	542.82
S_2F_2: 60 cm x 30 cm with 60:40:50 kg NPK ha^{-1}	3.56	98.28	126.62	594.65
S_2F_3: 60 cm x 30 cm with 90:60:75 kg NPK ha^{-1}	3.74	102.71	138.16	604.59
S_3F_1: 60 cm x 45 cm with 30:20:25 kg NPK ha^{-1}	2.58	73.56	142.37	533.44
S_3F_2: 60 cm x 45 cm with 60:40:50 kg NPK ha^{-1}	2.62	74.90	151.95	582.75
S_3F_3: 60 cm x 45 cm with 90:60:75 kg NPK ha^{-1}	3.12	83.42	168.35	676.58
SEm±	**0.10**	**2.78**	**3.82**	**16.66**
CD (P= 0.05)	**0.29**	**8.34**	**NS**	**49.94**

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