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Original Research Article

Influence of Methods of Establishment and Nutrient Management Practices on Growth, Yield and Quality of Chia (*Salvia hispanica* L.)

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A B S T R A C T

A field experiment was carried out to study the influence of methods of establishment and nutrient management practices on growth, yield and quality of Chia crop under Southern Dry Zone of Karnataka during *kharif* 2019. The experiment consists of twelve treatment combinations laid out in split plot design with three replications. The results of the study revealed that, transplanting method of establishment recorded significantly higher number of branches plant^{-1} (20.71),spikes plant^{-1} (44.67), seed yield (1043.85 kg ha^{-1}), haulm yield (3501.57 kg ha^{-1}),which was on par with line sowing than broadcasting method of establishment. Among nutrient management practices, application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) was recorded significantly higher number of branches plant^{-1} (20.99), spikes plant^{-1} (45.28), seed yield (1120.31 kg ha^{-1}), haulm yield (3266.83 kg ha^{-1}), followed by 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}), FYM (8 t ha^{-1}) and lower values were observed with control plot (No Fertilizers). Quality parameters viz., oil content, protein content and alpha linolenic acid content does not differed significantly due to methods of establishment but differed significantly due to nutrient management practices. Significantly higher oil and alpha linolenic acid content in control plot (29.90 and 55.93 % respectively) and higher protein content (23.07 %) with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}). The interaction effect between establishment methods and nutrient management practices was found non-significant.

Keywords

Chia, Methods of establishment, Nutrient management, Seed yield, Protein, Alpha linolenic acid

Introduction

Chia (*Salvia hispanica* L.) is a mint plant in the lamiaceae family, native to southern Mexico and Northern Guatemala (Ayerza and Coates, 2009) and now it is also cultivated in Southern parts of India. It is a staple food of the central America civilizations in pre-Columbian period, along with corn, beans and amaranthus (Fernandez *et al.*, 2006).It is considered as pseudo cereal and oil seed crop cultivated for edible purpose It is an annual herbaceous plant considered as a novel food, the area under cultivation of chia crop is expected to rise in the coming days as it requires less water and is a drought resistant crop comes up very well under dry land condition. Chia is a plant characterised by low water consumption and well adopted to arid and semi-arid regions (Ayerza, 1995).

The cultivation of chia is gaining popularity in Africa because it is considered as a good nutritional and healthy food. The plant has high percentage of fibre, protein, omega-3, omega-6 and essential fatty acids (Ayerza and Coates, 1999). It is grown for human consumption especially due to its richness in omega-3 fatty acids, fibre and is a great source of anti-oxidants and amino acids particularly lysine. The seeds contain about 20% protein, 35 % oil and an impressive 25% dietary fibre and also offer a range of vitamins and minerals including calcium, phosphorus magnesium and Zinc. In recent years, some farmers sowing interest to grow chia crop due to its nutrient content and climate resilience. Hence there is need to standardise agronomic practices for further popularisation of this crop which can play a major role in feature diversification of agriculture system in India.

Materials and Methods

A field experiment was conducted at Zonal Agriculture Research Station, Vishweshwaraiah Canal Farm, Mandya, University of Agriculture Sciences, GKVK, Bangalore during *kharif,* 2019 comes under Southern Dry Zone of Karnataka (Zone VI).The experimental site is situated between 11° 30' to 13° 05' North latitude and 76° 05' to 77° 45' East longitude with an altitude of 695 meters above the mean sea level (MSL). The experimental soil was sandy loam in texture.

The soil was neutral in reaction (pH 7.0), normal in electrical conductivity (0.34 dSm^{-1}), medium in organic carbon (0.60 %), medium in available nitrogen (244.13 kg ha^{-1}), high in available phosphorous (55.7 kg ha^{-1}) and medium in available potassium (226.3 kg ha^{-1}). The total rainfall received during the crop growth period was 737.2 mm and highest and lowest rainfall received in the month of September (150.4 mm) and October (145.2 mm) respectively. The experiment was laid out in split plot design with three replications, the methods of establishment in main plot (S_1: Broadcasting, S_2: Line sowing and S_3: Transplanting) and nutrient management practices [F_1: Control (No Fertilizers), F_2: FYM (8 t ha^{-1}), F_3: 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}) and F_4: 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})] were allotted to sub plots). The crop was raised in nursery and main field by mixing the seeds with fine sand in 1:2 ratio as per the treatments.

In transplanting, 18 days old seedlings were planted, seeds dibbled in line sowing with a depth of 5 cm and seeds were broadcasted in broadcasting methods of sowing. Full dose of phosphorus, potassium and fifty percent of recommended dose of nitrogen was applied as basal and remaining 50 per cent of recommended nitrogen was applied as top dressing as per the treatment details. Crop was raised by following agronomic practices and necessary plant protection was taken as and when pest and disease was noticed. Growth and yield parameters were recorded on randomly selected plants at 30, 60, 90 DAS/T and at harvest.

The quality parameters like oil, protein and fatty acid composition (α- linolenic acid, linoleic acid, oleic acid, palmitic acid and stearic acid) were determined by AOAC approved methods. Oil was estimated by the Soxhlet method using hexane as solvent.

Protein content was determined by FLASH 2000 N/Protein Analyzer using modified Dumas principle. Using GCMS (Gas Chromatography Mass Spectrometer) method, fatty acid composition of Chia seeds was analysed. Further, statistical analysis of the data was carried out as per the method suggested by Gomez and Gomez, 1984.

Results and Discussion

Effect of different methods of establishment and nutrient management practices on growth, yield parameters and yield of Chia

The data on growth parameters, seed yield and yield parameters of chia as influenced by method of establishment and nutrient management practices are presented in Table 1. Transplanting method of establishment recorded significantly taller plants and more number of branches (115.27 cmand20.71 respectively) and was on par with line sowing (112.38 cm and 19.83 respectively) than broadcasting method of sowing (100.45 cmand 16.36 respectively).

Among the nutrient management practices, application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) recorded higher plant height and number of branches (117.53 cm- 19.83 respectively) and found significantly superior over other nutrient levels in the study. This might be due to optimum plant population with lesser competition for resources and better availability of sunlight, maximum uptake of nutrients and water by individual plants. These results are in accordance with the findings of Mary *et al.,* (2018) and Dos Santos *et al.,* (2019). Interaction effect between establishment methods and nutrient management practices was found to be non-significant.

Number of spikes had shown a significant difference on methods of establishment and nutrient management practices.

Transplanting method of establishment recorded significantly higher number of spikes (44.67) and was on par with line sowing (43.29) compared to broadcasting method of establishment (37.64). Among nutrient management practices higher number of spikes (45.28) was recorded with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) and superior over other nutrient levels. Interaction effect between nutrient management practices and establishment methods was found non- significant. Due to increase in spacing and fertilizer dosage, more space will be available for each plant and competition between plants will be less.

Significantly higher seed yield (1043.85 kg ha^{-1}) was recorded in transplanting method of establishment and was on par with line sowing (973.91 kg ha^{-1}) compared to broadcasting method of establishment (821.41 kg ha^{-1}).

Among the nutrient management practices, application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) resulted higher seed yield (1120.31 kg ha^{-1}) followed by application of 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1})(1008.70kg ha^{-1}) and lowest seed yield was obtained in control plot (726.48 kg ha^{-1}). Interaction effect between nutrient levels and establishment methods was found non-significant.

Significantly higher haulm yield (3501.57 kg ha^{-1}) of chia was recorded with transplanting method of establishment which was on par with line sowing (3006.91 kg ha^{-1}) and lower haulm yield was recorded in broadcasting method of establishment (2590.55 kg ha^{-1}).

Among nutrient management practices, higher haulm yield was recorded with the application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (3266.83 kg ha^{-1}) which was on par with nutrient level 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (3098.87 kg ha^{-1}) and lower haulm yield was recorded in control plot (2824.60 kg ha^{-1}). Interaction effect between establishment methods and nutrient management practices did not show any significant influence on haulm yield.

Table.1 Growth, yield and yield parameters of Chia as influenced by methods of establishment and nutrient management practices

Treatments	Plant height (cm)	No. of branches plant^{-1}	No. of Spikes (plant^{-1})	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Test weight (g)
Method of establishment (S)						
S_1: Broadcasting	100.45	16.36	37.64	821.41	2590.55	1.24
S_2: Line sowing	112.38	19.83	43.29	973.91	3006.91	1.30
S_3: Transplanting	115.27	20.71	44.67	1043.85	3501.57	1.33
F-test	*	*	*	*	*	NS
S. Em.+	**2.02**	**0.43**	**0.99**	**22.51**	**71.01**	**0.02**
C.D. (p=0.05)	**8.18**	**1.75**	**4.00**	**90.76**	**286.30**	-
Nutrient management practices (F)						
F_1: Control (No fertilizers)	103.30	17.18	38.81	726.48	2824.60	1.21
F_2: FYM (8 t ha^{-1})	106.56	18.06	40.13	930.07	2941.74	1.26
F_3: 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	110.08	19.63	43.24	1008.70	3098.87	1.31
F_4: 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	117.53	20.99	45.28	1120.31	3266.83	1.39
F-test	*	*	*	*	*	*
S. Em.+	**2.03**	**0.49**	**1.29**	**31.48**	**90.13**	**0.02**
C.D. (p=0.05)	**6.09**	**1.49**	**3.87**	**94.26**	**269.87**	**0.08**
Interaction (S x F)						
S_1F_1	93.87	14.22	32.50	630.53	2428.36	1.19
S_1F_2	96.57	15.80	34.93	822.02	2449.98	1.22
S_1F_3	101.21	17.05	40.44	870.30	2728.34	1.24
S_1F_4	110.16	18.37	42.70	962.80	2755.51	1.32
S_2F_1	106.34	18.39	41.70	739.89	2909.84	1.21
S_2F_2	110.98	18.92	42.03	958.87	3014.78	1.27
S_2F_3	113.55	20.65	44.37	1035.30	2835.14	1.31
S_2F_4	118.66	21.35	45.05	1161.60	3267.86	1.40
S_3F_1	109.69	18.92	42.23	809.03	3135.59	1.23
S_3F_2	112.12	19.47	43.43	1009.33	3360.46	1.29
S_3F_3	115.49	21.19	44.93	1120.51	3733.12	1.38
S_3F_4	123.76	23.25	48.10	1236.53	3777.12	1.44
F-test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S. Em.+	**3.66**	**0.86**	**2.18**	**61.30**	**152.71**	**0.04**
C.D. (p=0.05)	-	-	-	-	-	-

Table.2 Influenced of methods of establishment and nutrient management practices on quality parameters of chia

Treatments	Oil content (%)	Protein content (%)	Fatty acid composition (%)				
			ALA	LA	OA	PA	SA
Method of establishment (S)							
S_1: Broadcasting	26.25	21.23	53.62	21.97	10.82	8.80	3.95
S_2: Line sowing	27.52	22.24	54.50	22.39	11.47	8.91	4.09
S_3: Transplanting	27.70	22.65	55.27	22.42	11.97	9.17	4.22
F-test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S. Em.±	**0.74**	**0.45**	**0.39**	**0.16**	**0.23**	**0.13**	**0.05**
C.D. (p=0.05)	-	-	-	-	-	-	
Nutrient management practices (F)							
F_1: Control (No fertilizers)	29.90	21.11	55.93	21.71	10.69	8.60	4.00
F_2: FYM (8 t ha^{-1})	28.15	21.79	54.47	22.26	10.97	8.98	4.04
F_3: 40:20:20 NPK $kgha^{-1}$ + FYM (8 t ha^{-1})	25.76	22.18	54.21	22.40	11.65	9.11	4.12
F_4: 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	24.82	23.07	53.25	22.67	12.37	9.15	4.19
F-test	*	*	*	*	*	**NS**	**NS**
S. Em.±	**0.65**	**0.37**	**0.62**	**0.11**	**0.37**	**0.15**	**0.06**
C.D. (p=0.05)	**1.95**	**1.11**	**1.85**	**0.34**	**1.12**	-	-
Interaction (S x F)							
S_1F_1	27.72	20.38	54.16	21.08	9.57	8.34	3.82
S_1F_2	26.75	20.53	53.67	22.12	10.38	8.86	3.84
S_1F_3	25.46	21.28	53.64	22.23	11.36	8.99	4.04
S_1F_4	25.06	22.71	53.02	22.47	11.97	9.02	4.08
S_2F_1	30.47	20.64	56.41	22.13	11.26	8.53	3.99
S_2F_2	27.47	22.37	54.34	22.27	11.31	8.91	4.10
S_2F_3	26.58	22.52	54.29	22.51	11.43	9.09	4.11
S_2F_4	25.55	23.43	52.97	22.65	11.86	9.10	4.18
S_3F_1	31.49	22.31	57.23	21.93	11.24	8.92	4.18
S_3F_2	30.22	22.48	55.41	22.38	11.20	9.16	4.19
S_3F_3	25.23	22.74	54.68	22.46	12.16	9.27	4.20
S_3F_4	23.85	23.08	53.76	22.90	13.28	9.34	4.31
F-test	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
S. Em.±	**0.99**	**0.48**	**1.42**	**0.33**	**0.46**	**0.26**	**0.11**
C.D. (p=0.05)	-	-	-	-	-	-	-

ALA: Alpha Linolenic Acid, LA: Linoleic Acid, PA: Palmitic Acid, SA: Stearic Acid, OA: Oleic Acid

The increased in yield and yield components might be due to increase in cell elongation, nutrient uptake by plants, increased photosynthates and better translocation of nutrients to site of utilization which results to higher leaf area, leaf area index and dry matter production. The results of the investigation are in confirmation with the findings of Mary *et al.,* (2018) and Dos Santos *et al.,* (2019).

Effect of different methods of establishment and nutrient management practices on quality parameters of Chia

The data on oil, protein and fatty acid composition of seeds as influenced by methods of establishment and nutrient management practices are given in Table 2.

Oil and protein content of chia did not differ significantly due to methods of establishment but differed significantly with respect to nutrient management practices. Among nutrient levels, significantly higher oil content was observed with no fertilizer applied plot (29.90 %) and was on par with application of FYM (8 t ha^{-1}) (28.15 %) and lower oil content was recorded in treatment 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (24.82 %). The highest oil content in lower nutrient management plot was might be due to decreasing N-compounds in the seed oil.

Among nutrient management practices, significantly higher protein content was noticed with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (23.07 %) which was on par with application of 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (22.18 %) compared to other treatments in the study. Increase in protein content might be due to addition of more nitrogen fertilizers which resulted in more protein content in seeds. These results were in line with Mary *et al.,* (2018) and Grimes *et al.,* (2019).

The methods of establishment did not show any significant influence on fatty acid composition of oil present in seeds, however fertilizer level (F_1) had profound effect on fatty acid contents and recorded 55.93 per cent Alpha Linolenic Acid content which was on par with F_2 (54.47 %). The lower fertilizer level contributed more for ALA content in oil. PA and SA content was recorded higher (9.15 % and 4.19 %, respectively) with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) and was on par with F_3 (9.11 % and 4.12 %, respectively). Similar results were reported by Silva *et al.,* (2015) and Ixtaina *et al.,* (2011). The interaction of different methods of establishment and fertilizer levels did not show any significant difference in fatty acid composition of oil in Chia seeds.

Based on the results obtained it can be inferred that, transplanting method of establishment with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) resulted significantly higher seed yield and was on par with line sowing method of establishment with application of 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1}). Protein content (23.07 %) of chia was increased with increase in fertilizer level and the composition of fatty acids did not show any significant difference due to the influence of methods of establishment and nutrient management practices.

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