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Yield and Economics of Chia (*Salvia hispanica* L.) as influenced by different Methods of Establishment and Nutrient Management Practices in Southern Dry Zone of Karnataka

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ABSTRACT: Chia is a very important super food crop with lots of medicinal value getting more popularity in recent days because of its healthy omega-3 fatty acid content. The cultivation of Chia in India was started by very few farmers now a day's demand for Chia has increased due to its nutrient content and encouraging farmers to cultivate the crop. In this regard's suitable methods of establishment with adequate spacing and fertilizer management is considered as a base that leads to development of production technology which can influence the healthy seed yield and yield attributes which are most important components of systematic cultivation that could enhance productivity and profitability of crop. The field experiment was carried out at Zonal Agricultural Research Station, V.C. Farm, Mandya during *kharif* 2019 to evaluate the suitable methods of establishment and nutrient management practices on yield and economics of Chia (*Salvia hispanica*). The experiment comprised twelve treatment combinations laid out in split-plot design with three replications. The results of the study revealed that transplanting method of Chia cultivation resulted in significantly higher seed yield (1043.8 kg ha^{-1}), gross income (Rs.167016 ha^{-1}), net returns (Rs.128542 ha^{-1}) and B:C ratio (4.34) and was on par with line sowing than broadcasting methods of establishment. Among nutrient management practices, application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) resulted significantly higher seed yield (1120.3 kg ha^{-1}), gross returns (Rs.179250 ha^{-1}), net returns (Rs.136323 ha^{-1}) and B: C ratio (4.18) followed by application of 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}), FYM (8 t ha^{-1}) and found significantly superior over other treatments in the study.

Keywords: Chia, establishment, fertilizers, gross income and seed yield.

INTRODUCTION

Chia (*Salvia hispanica* L.), is an oil-rich annual herbaceous plant of the Lamiaceae (mint) family and native to mountain areas of Mexico and Guatemala (Ixtaina *et al*., 2008). It has been consumed and domesticated as a staple food crop by Mesoamerican Indian tribes since 2600 B.C. 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 has opposite arranged leaves. Chia seeds can be a food supplement due to its high contents of polyunsaturated fatty acids, anti-oxidants, vitamins, minerals, and protein in seeds (Ayerza *et al.,* 2002). Chia is a plant characterized by low water requirement and well adapted to arid and semiarid regions it is cultivated in the worldwide with an area of 126 thousand hectares with a production of 103 thousand tonnes. Bolivia in South America is the largest producer of Chia with 38 per cent of world production (Peperkamp, 2015) followed by Peru with 32 per cent and United States of America with 6.3 per cent. Chia plants can grow very well in sandy loam, well-drained soils with a low nutrient content, moderate salinity, and soil having pH of 6-8.5 (Yeboah *et al.*, 2014). The duration of crop cycle is most cases from 140 to 180 days, but since Chia is extremely sensitive to photoperiodic day length (a macro-thermal short-day species), the growing cycle absolutely depends on the latitude where it is planted.

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 edapho climatic characteristics of each region. Considering the increasing various demand for Chia due to its nutrient content and climate resilience and the information on agronomic management and the importance of nitrogen fertilization of crops in soils of Karnataka is meagre which was an incentive to this work. In this regard suitable methods of establishment and nutrient management practices are considered as a base that leads to development of production technology especially for a new crop in a particular region due to better crop establishment with adequate spacing and nutrient management practices plant could gain

sufficient water, sunlight and nutrients from the soil, which can influence the healthy seed yield and yield attributes are most important components of systematic cultivation that could enhance productivity and profitability of crop. Therefore, there is a need to standardize the production technologies for better growth and higher productivity and profitability of Chia crop.

MATERIAL AND METHODS

The field experiment was conducted at Zonal Agriculture Research Station, Vishweshwaraiah Canal Farm, Mandya, University of Agriculture Sciences, GKVK, Bengaluru 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 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 experimental soil was sandy loam in texture with neutral in reaction (pH 7.0), normal in electrical conductivity (0.34 dSm^{-1}), medium in organic carbon (0.60 %), available nitrogen (244.13 kg ha^{-1}), available phosphorous (32.7 kg ha^{-1}) and available potassium (226.3 kg ha^{-1}). The experiment consists of twelve treatment combinations was laid out in split plot design with three replications. The methods of establishment allotted to 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 ratios as per the treatments. In transplanting, 18 days old seedlings were planted, seeds dibbled in line sowing and broadcasted in broadcasting methods of sowing. Full dose of phosphorus and potassium were applied as basal at transplanting while 50 percent of recommended nitrogen was applied as basal and remaining half was applied as top dressing at 20 DAT. Growth and yield parameters were recorded on randomly selected plants at 30, 60, 90 DAS/T and at harvest. The economics viz; cost of cultivation, gross returns, net returns and B: C ratio was calculated with prevailing market price for output and input costs. Further, statistical analysis of the data was carried out adopting Fisher's methods of analysis of variance (ANOVA) as outlined by Gomez and Gomez (1984) for interpretation of results and draw conclusion.

RESULTS AND DISCUSSION

A. Yield and yield attributes of chia as influenced by methods of establishment and nutrient management practices

Yield and yield attributes of Chia varied significantly due to methods of establishment and nutrient management practices and are presented in Table 1. Transplanting method of establishment recorded significantly higher number of spikes $plant^{-1}$ and length of spike (44.6 and 30.3 cm respectively) was on par with line sowing (43.2 and 27.5 cm respectively) over broadcasting method of sowing (37.6 and 22.7 cm respectively). Among nutrient management practices, higher number of spikes $plant^{-1}$ and length of spike was recorded with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (45.2 and 29.0 cm respectively) and was on par with 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (43.2- 27.3 cm respectively) and lower values was observed in control plot wherein no fertilizer applied (38.8-25.3 cm respectively). Interaction effect between establishment methods and nutrient levels was found non-significant.

Transplanting method of establishment produced significantly higher seed yield and haulm yield (1043.8 kg ha^{-1} and 3501.5 kg ha^{-1} respectively) and was on par with line sowing (973.9 kg ha^{-1} and 3006.9 kg ha^{-1} respectively) and lower seed and haulm yield was recorded in broadcasting method of establishment (821.4 kg $ha^{-1}$and 2590.5 kg ha^{-1}respectively) (Table 1). Among the nutrient management practices, application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (1120.3 kg ha^{-1} and 3266.8 kg ha^{-1} respectively) resulted significantly higher seed yield and haulm yield followed by 40:20:20 NPK kg/ha + FYM (8 t ha^{-1}) (1008.7 kg ha^{-1} and 3098.8 kg ha^{-1} respectively) and found significantly superior over other treatments in the investigation. This result was in accordance with the data recorded by Punyasloka Mohanty *et al*. (2021). However, the lowest yield was observed in control plot (726.4 kg $ha^{-1}$and 2824.6 kg ha^{-1} respectively). Interaction effect between nutrient management practices and establishment methods was found non-significant. The increased in yield and yield components might be due to better growth and yield attributing characters like number of branches, leaves, leaf area, dry matter production, number of spikes and spikelet's and test weight. The results of the investigation are in confirmation with the findings of Wang *et al.* (2014); Manasa *et al.* (2020); Mary *et al*. (2018).

B. Economics of Chia as influenced by methods of establishment and nutrient management ***practices***

Gross returns, net returns and B:C ratio of Chia crop varied due to methods of establishment and nutrient management practices. Transplanting method of Chia recorded higher net returns (128542 Rs. ha^{-1}) and B:C ratio (4.34) followed by line sowing (118897 Rs. $ha^{-1}$and 4.22 respectively) and lower values was observed in broadcasting method of establishment (96408 Rs. $ha^{-1}$and 3.75 respectively). Among nutrient management practices, higher net returns (136323 Rs. ha^{-1}) and B: C ratio (4.18 were registered with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) followed by 40:20:20 NPK kg ha^{-1} + FYM (8 t ha^{-1}) (122238 Rs. ha^{-1}) and lower was observed in control plot (86054 Rs. ha^{-1} and 3.85 respectively) (Table 2) This result was in accordance with the data recorded by Mary *et al*. (2018). The higher gross returns, net returns and B: C ratio was mainly due to higher seed yield and prevailing higher market prices were reported by Mansour *et al.* (2017).

Table 1: Yield and yield attributes of Chia as influenced by methods of establishment and nutrient management practices.

Treatments	No. of Spikes (plant^{-1})	Length of spike (cm)	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Test weight (g)
Method of establishment (S)					
S_1: Broadcasting	37.6	22.7	821.4	2590.5	1.24
S_2: Line sowing	43.2	27.5	973.9	3006.9	1.30
S_3: Transplanting	44.6	30.3	1043.8	3501.5	1.33
F-test	*	*	*	*	NS
S. Em.+	**0.99**	**0.63**	**22.51**	**71.01**	**0.02**
C.D. (p=0.05)	**4.00**	**2.53**	**90.76**	**286.30**	-
Nutrient management practices (F)					
F_1: Control (No fertilizers)	38.8	25.3	726.4	2824.6	1.21
F_2: FYM (8 t ha^{-1})	40.1	25.8	930.0	2941.7	1.26
F_3: 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	43.2	27.3	1008.7	3098.8	1.31
F_4: 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	45.2	29.0	1120.3	3266.8	1.39
F-test	*	*	*	*	*
S. Em.+	**1.29**	**0.84**	**31.48**	**90.13**	**0.02**
C.D. (p=0.05)	**3.87**	**2.53**	**94.26**	**269.87**	**0.08**
Interaction (S x F)					
S_1F_1: Broadcasting with control (No fertilizers)	32.5	20.9	630.5	2428.3	1.19
S_1F_2: Broadcasting with FYM (8 t ha^{-1})	34.9	21.4	822.0	2449.9	1.22
S_1F_3: Broadcasting with 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	40.4	23.8	870.3	2728.3	1.24
S_1F_4: Broadcasting with 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	42.7	24.6	962.8	2755.5	1.32
S_2F_1: Line sowing with control (No fertilizers)	41.7	26.4	739.8	2909.8	1.21
S_2F_2: Line sowing with FYM (8 t ha^{-1})	42.0	26.8	958.8	3014.7	1.27
S_2F_3: Line sowing with 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	44.3	27.0	1035.3	2835.1	1.31
S_2F_4: Line sowing with 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	45.0	30.0	1161.6	3267.8	1.40
S_3F_1: Transplanting with control (No fertilizers)	42.2	28.6	809.0	3135.5	1.23
S_3F_2: Transplanting with FYM (8 t ha^{-1})	43.4	29.0	1009.3	3360.4	1.29
S_3F_3: Transplanting with 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	44.9	31.1	1120.5	3733.1	1.38
S_3F_4: Transplanting with 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	48.1	32.3	1236.5	3777.1	1.44
F-test	**NS**	**NS**	**NS**	**NS**	**NS**
S. Em.+	**2.18**	**1.41**	**61.30**	**152.71**	**0.04**
C.D. (p=0.05)	-	-	-	-	-

Table 2: Economics of Chia as influenced by methods of establishment and nutrient management practices.

Treatments	Cost of Cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
Main plot: Method of establishment (S)				
S_1: Broadcasting	35018	131426	96408	3.75
S_2: Line sowing	36929	155826	118897	4.22
S_3: Transplanting	38475	167016	128542	4.34
Sub plot: Nutrient management practices (F)				
F_1: Control (No fertilizers)	30183	116237	86054	3.85
F_2: FYM (8 t ha^{-1})	36398	148812	112413	4.09
F_3: 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	39155	161393	122238	4.12
F_4: 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	42927	179250	136323	4.18
Interaction (S × F)				
S_1F_1: Broadcasting with control (No fertilizers)	30950	100885	69935	3.26
S_1F_2: Broadcasting with FYM (8 t ha^{-1})	35100	131523	96423	3.75
S_1F_3: Broadcasting with 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	37020	139249	102229	3.76
S_1F_4: Broadcasting with 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	41002	154048	113046	3.76
S_2F_1: Line sowing with control (No fertilizers)	32200	118382	86182	3.68
S_2F_2: Line sowing with FYM (8 t ha^{-1})	36752	153419	116667	4.17
S_2F_3: Line sowing with 40:20:20 NPK	39012	165648	126636	4.25

kgha^{-1} + FYM (8 t ha^{-1})				
S_2F_4: Line sowing with 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	42654	185856	143202	4.36
S_3F_1: Transplanting with control (No fertilizers)	34100	129444	95344	3.80
S_3F_2: Transplanting with FYM (8 t ha^{-1})	37343	161494	124151	4.32
S_3F_3: Transplanting with 40:20:20 NPK kgha^{-1} + FYM (8 t ha^{-1})	41432	179282	137850	4.33
S_3F_4: Transplanting with 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1})	45123	197845	152722	4.38

(A) Chia Seed

(B) Germination test

(C) Chia Plant

(D) Transplanting method of establishment with 60:40:40 NPK kg ha^{-1}+FYM 8 t ha^{-1}

CONCLUSIONS

Optimum seed yield with greater net returns and B:C ratio was recorded with transplanting method of establishment with application of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) and was found economical and sustainable compared to control plots. So, it can be recommended for transplanting method of cultivation with fertilizer dosage of 60:40:40 NPK kg ha^{-1} + FYM (8 t ha^{-1}) for getting maximum yield coupled with superior quality seed and higher returns.

Conflict of Interest. None.

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