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Influence of sowing methods and foliar nutrition on growth parameters of chia (*Salvia hispanica* L.)

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Abstract
A field experiment was conducted during Rabi season of 2024-25 at on the field of a contact farmer of ICAR-Krishi Vigyan Kendra (KVK), Bidar, at Hupla village, Bhalki taluk, Bidar district to study the effect of sowing methods and foliar nutrient applications on growth parameters of chia (*Salvia hispanica* L.). The experiment was laid out in a Factorial Randomized Block Design (FRBD) comprising two sowing methods M_1: Direct sowing, M_2: Transplanting) and eleven foliar nutrient treatments (T_1) Control, (T_2) Humic acid @ 0.1%, (T_3) Salicylic acid @ 0.01%, (T_4) Vermiwash @ 5%, (T_5) Jeevamrutha @ 5%, (T_6) Panchagavya @ 5%, (T_7) 19:19:19 @ 1%, (T_8) Bio NPK @ 10%, (T_9) Biochar @ 0.3%, (T_{10}) *Metarhizium anisopliae* @ 5%, (T_{11}) *Beauveria bassiana* @ 5%with three replications and were applied at 30 and 45 DAP. The results revealed that transplanting of seedlings along with foliar spray of 19:19:19 @ 1% (M_2F_7) recorded significantly higher plant growth parameters *viz*., Plant height (120.47 cm), Number of primary branches (13.44), Number of secondary branches (34.87), Less days for spike initiation (27.33) and Less days to 50% flowering (35.67), Whereas, direct sowing with control (M_1F_1) recorded the lowest values (99.33 cm, 9.08, 21.67, 37.00 days, 44.48 days, respectively). The superior performance of 19:19:19 is attributed to balanced and readily available macro-nutrients that enhanced photosynthesis, assimilate translocation and overall plant metabolism. Similarly, transplanting ensured vigorous crop establishment,

Keywords: Chia, transplanting and foliar nutrient application

Introduction
Chia (*Salvia hispanica* L.) was used as a super food from ancient times. In recent days with increase in the health awareness throughout the world, it demands for healthy food, using chia seeds in daily diet may prevent many diseases (diabetes, obesity and cardiovascular). Chia was domesticated almost 4,500 years ago in Mesoamerica and it was used as food and medicine. Chia seed is composed of high dietary fibre (18-30%), ash (4-5%), protein (15-25%), fats (30-33%), lipids (31-35%), carbohydrates (26-41%), minerals, vitamins and a high amount of antioxidants. It is having higher concentration of PUFAs (Poly Unsaturated Fatty Acids) of omega-3 (58-64% of the total lipids) and omega-6 essential fatty acids The plant reaches up to 1 Meter height and bears white to purple hermaphrodite flowers. Seeds are tiny, oval-shaped and vary in color from black and grey to white, showing similar nutritional composition (Bushway *et al.*, 1981) [3]. Chia seeds are highly nutritious, rich in Omega-3 fatty acids, high-quality protein, dietary fiber, minerals, vitamins and antioxidants (Vuksan *et al.*, 2010) [21]. Their popularity as a "superfood" has increased due to health benefits like reduced cardiovascular risk and gluten-free nature.
Globally, production is dominated by Mexico and Latin America, but cultivation is expanding to Australia, Europe and India (Ayerza and Coates, 2005) [2]. In India, it is increasingly grown in Karnataka, Rajasthan, Haryana and Uttarakhand, with CFTRI Mysore playing a key role in its promotion. However, limited agronomic research exists, particularly on sowing techniques, nutrient management and seed technology. Since quality seed is crucial for a good crop, scientific evaluation under Indian conditions is needed.
Foliar nutrition is gaining importance due to its fast nutrient absorption and improved efficiency, especially where soil limitations restrict nutrient uptake (Fageria*et al.*, 2009 and Fernández and Brown, 2013) [7, 8]. It enhances growth, flowering, seed development and ultimately improves yield and seed quality, including oil and antioxidant content (Mikkelsen, 2016 and Prasad *et al.*, 2014) [13, 15].

Material and Methods
The field experiment was conducted at farmer field of ICAR-Krishi Vigyan Kendra (KVK), Bidar contact farmer, at Hupla village, Tq. Bhalki, Dist. Bidar, during Rabi 2024-25. The location falls under the North-Eastern Dry Zone of Karnataka. Geographically, the site is situated at 18.06° N latitude and 77.30° E longitude, with an altitude of 607 m above mean sea level (MSL).
The experiment was laid out in a Factorial Randomized Block Design (FRBD) with three replications consisting of two sowing methods and eleven foliar nutrient treatments. The treatments included Control, Humic Acid @ 0.1 %, Salicylic Acid @ 0.01 %, Vermiwash @ 5 %, Jeevamrutha @ 5 %, Panchagavya @ 5 %, 19:19:19 @ 1 %, Bio NPK @ 10 %, Biochar @ 0.3 %, *Metarhizium anisopliae* @ 5 % and *Beauveria bassiana* @ 5 %, applied at 30 and 45 days after planting.

During the course of investigation, in order to assess the effect of sowing methods and foliar nutrient sprays on growth parameters of chia seeds, observations were recorded at different growth stages using standard procedures.

Results and Discussion

The results on growth and yield parameters *viz*., plant height (cm), number of primary and secondary branches, days to spike initiation, days to 50 per cent flowering, number of spikes per plant, spike length (cm), seed yield per spike (g), seed yield per plant (g),seed yield per hectare (kg ha^{-1}) and test weight (g) Influenced by sowing methods and foliar nutrient applications are summarized in Tables 1 to 4.

Plant height (cm)

The plant height of chia was significantly influenced by sowing methods at all stages (30, 90 days after planting and at harvest). Foliar nutrient application had no effect at 30 DAP but showed significant influence at 90 DAP and harvest. The interaction (M × F) remained non-significant. At 30 DAP, transplanting (M_2) produced significantly taller plants (72.83 cm) than direct sowing (M_1: 19.74 cm), owing to better early establishment and pre-developed roots. Similar early advantages of transplanting were reported by Kumar *et al.* (2018) and Rana *et al.* (2020) [11, 17]. At 90 and harvest, direct sowing (M_1) surpassed transplanting, recording 111.99 cm and 123.82 cm respectively, compared to 96.74 cm (M_2). This shift was likely due to uninterrupted root growth and the absence of transplant shock. Comparable results were observed by Singh *et al.* (2017) and Patel *et al.* (2019) [9, 14].

Among foliar treatments, significant variation appeared from 90. At harvest, the tallest plants were produced with 19:19:19 @ 1 % (F_7: 120.47 cm), followed by Bio NPK @ 10 % (F_8: 118.57 cm) and Panchagavya @ 5 % (F_6: 116.70 cm). The lowest height was in the control (F_1: 99.33 cm). The superiority of 19:19:19 may be due to balanced nutrient supply enhancing vegetative growth.

Although statistically non-significant, the highest numerical plant height occurred under direct sowing + 19:19:19 @ 1 % (M_1F_7: 139.89 cm), indicating a possible synergistic improvement. Similar non-significant but positive trends were reported by Kiran *et al.* (2021) and Das *et al.* (2018) [6, 10].

Number of primary branches

The number of primary branches in chia was significantly influenced by the sowing method at all growth stages, while foliar nutrient application became significant only at 90 DAP and harvest. The interaction (M × F) remained non-significant.

At 30, transplanting (M_2) recorded a higher number of primary branches (7.70) than direct sowing (M_1: 2.85), due to better early establishment. This advantage continued through 90 (M_2: 11.97 vs. M_1: 9.79) and harvest (M_2: 11.97 vs. M_1: 10.60), showing that transplanting consistently improved branching. Similar results have been reported in sesame and sunflower (Kumar *et al.*, 2018; Rana *et al.*, 2020) [11, 17]. Among foliar treatments, the maximum branches at harvest were recorded with 19:19:19 @ 1 % (F_7: 13.44), followed by Bio NPK @ 10 % (F_8: 12.98) and Panchagavya @ 5 % (F_6: 12.49). The lowest value was in the control (F_1: 9.08). Although not statistically significant, these results showed that foliar feeding improved vegetative branching. Similar positive effects of foliar nutrition were reported by Sharma *et al.* (2016) and Das *et al.* (2018) [6, 16].

The M × F interaction was non-significant, but the highest numerical branching occurred in transplanting + 19:19:19 @ 1 % (M_2F_7: 13.93), indicating a possible additive effect. Comparable trends were noted by Kiran *et al.* (2021) [10] in linseed, where establishment methods combined with foliar sprays enhanced vegetative growth.

Number of secondary branches

The number of secondary branches in chia was significantly influenced by the sowing method at 90 DAP and harvest, while foliar nutrient application and the M × F interaction remained non-significant at all stages. This shows that the sowing method, particularly transplanting, had a stronger effect on secondary branching than foliar treatments.

Transplanting (M_2) showed a clear and significant advantage, producing 36.41 secondary branches compared to 13.58 under direct sowing (M_1). This superiority persisted until harvest (36.41 vs. 17.84). The enhanced branching under transplanting may be due to better early establishment and canopy development, similar to findings in sesame and chickpea (Kumar *et al.*, 2018; Singh & Meena, 2017) [9, 11].

With respect to foliar treatments, the maximum secondary branches at harvest were observed with 19:19:19 @ 1 % (F_7: 34.87), followed by Bio NPK @ 10 % (F_8: 31.62) and Panchagavya @ 5 % (F_6: 30.28). The lowest was recorded in the control (F_1: 21.67). Although not statistically significant, these numerical differences indicate that foliar sprays supported vegetative branching, as also reported in mustard and soybean (Sharma *et al.*, 2016; Das *et al.*, 2018) [6, 16]. The M × F interaction was non-significant; however, the highest number of secondary branches occurred under transplanting + 19:19:19 @ 1 % (M_2F_7: 45.40) at both 90 DAS and harvest, suggesting a possible additive effect. Similar non-significant but positive trends have been noted in linseed and sunflower (Kiran *et al.*, 2021; Rana *et al.*, 2020) [10, 17].

Days to spike initiation

The days to spike initiation in chia were significantly influenced by both the sowing method and foliar nutrient applications, while the interaction (M × F) remained non-significant. This indicates that transplanting and foliar sprays independently accelerated spike initiation, but their combined effect was not statistically distinct.

Transplanting (M_2) led to much earlier spike initiation (20.27 days) compared to direct sowing (M_1: 42.82 days), advancing the reproductive phase by nearly 22 days. This highlights the strong advantage of transplanting in promoting quicker crop establishment and earlier transition to flowering. Similar reductions in crop duration due to transplanting were reported in sesame, quinoa and chickpea (Kumar *et al.*, 2018; Patel *et al.*, 2019; Singh and Meena, 2017) [9, 11, 14].

Among foliar treatments, the earliest spike initiation occurred with 19:19:19 @ 1 % (F_7: 27.33 days), followed by Bio NPK @ 10 % (F_8: 28.00 days) and Panchagavya @ 5 % (F_6: 28.83 days). The control (F_1: 37.00 days) showed the longest duration. The advancement under foliar sprays may be due to enhanced nutrient availability and growth regulators promoting faster physiological development, as also noted in mustard and soybean (Sharma *et al.*, 2016; Das *et al.*, 2018) [6, 16].

Days to 50 % flowering

The number of days required to reach 50% flowering in chia was significantly affected by both the sowing method and foliar nutrient applications, Transplanting (M_2) resulted in much earlier flowering (28.75 days) compared to direct sowing (M_1: 51.02 days), a difference of over 22 days. This demonstrates the clear advantage of transplanting in reducing early stress, enhancing root development and hastening the shift to the reproductive stage. Similar benefits of transplanting in advancing flowering have been reported in pulses and oilseed crops (Choudhary *et al.*, 2015; Jat *et al.*, 2017; Patel *et al.*, 2020) [9].

Among foliar treatments, the earliest flowering was recorded with 19:19:19 @ 1 % (F_7: 35.67 days), followed by Bio NPK @ 10 % (F_8: 36.14 days) and Panchagavya @ 5 % (F_6: 37.34 days). The control (F_1: 44.48 days) took the longest time. Earlier flowering under foliar sprays may be due to rapid nutrient availability and improved physiological and hormonal activity, as also observed in soybean, groundnut and pigeonpea (Rajput *et al.*, 2016; Kumari *et al.*, 2018; Verma *et al.*, 2021) [12, 16].

Table 1: Influence of methods of sowing and foliar application ofnutrientson the plant height of chia at 30, 90 days and at harvest

Treatments	Plant height (cm)								
	30 days			90 days			At harvest		
	M_1(DAP)	M_2(DAP)	Mean	M_1(DAP)	M_2(DAP)	Mean	M_1(DAP)	M_2(DAP)	Mean
F_1	19.92	72.17	46.05	94.48	91.56	93.02	107.09	91.56	99.33
F_2	19.84	76.62	48.23	113.11	98.28	105.69	124.47	98.28	111.37
F_3	19.70	71.45	45.58	109.81	95.83	102.82	122.13	95.83	108.98
F_4	19.83	74.80	47.32	121.74	98.50	110.12	132.05	98.50	115.28
F_5	19.57	69.94	44.75	108.99	95.73	102.36	121.97	95.73	108.85
F_6	19.76	75.35	47.55	124.23	99.83	112.03	133.57	99.83	116.70
F_7	19.54	70.86	45.20	127.42	101.05	114.23	139.89	101.05	120.47
F_8	19.76	73.80	46.78	126.35	99.93	113.14	137.21	99.93	118.57
F_9	19.82	73.34	46.58	99.28	92.50	95.89	112.86	92.50	102.68
F_{10}	19.63	70.74	45.18	106.22	95.70	100.96	116.91	95.70	106.31
F_{11}	19.72	72.05	45.89	100.22	95.21	97.72	113.84	95.21	104.52
Mean	19.74	72.83		111.99	96.74		123.82	96.74	
	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
M	0.40	1.15		0.95	2.72		0.96	2.75	
F	0.94	NS		2.24	6.38		2.26	6.46	
M X F	1.34	NS		3.16	NS		3.20	NS	

Legend:
DAS: - Days after sowing DAT: - Days after transplanting
M_1:- Direct sowing F_1: - Control (water spray) F_5: - Jeevamrutha @ 5% F_9: - Biochar @ 0.3 %
M_2: - Transplanting of 21th F_2: - Humic Acid @ 0.1% F_6: - Panchagavya @ 5% F_{10}: - *Metarhizium anisopliae* @ 5%
days seedlings F_3: - Salicylic Acid @ 0.01 % F_7: - 19 All (19:19:19) @ 1% F_{11}: - *Beauveria bassiana* @ 5%
NS: - Non significant F_4: - Vermi wash @ 5% F_8: - Bio NPK @ 10%

Table 2: Influence of methods of sowing and foliar application ofnutrientson the number of primary branches ofchia at 30, 90 days and at harvest

Treatments	Number of primary branches								
	30 days			90 days			At harvest		
	M_1(DAS)	M_2(DAT)	Mean	M_1(DAS)	M_2(DAT)	Mean	M_1(DAS)	M_2(DAT)	Mean
F_1	2.63	7.76	5.20	7.68	10.09	8.89	8.07	10.09	9.08
F_2	3.00	7.36	5.18	10.74	12.20	11.47	11.48	12.20	11.84
F_3	3.18	7.77	5.48	9.10	12.03	10.56	11.25	12.03	11.64
F_4	2.46	8.39	5.43	11.27	12.41	11.84	11.89	12.41	12.15
F_5	2.63	7.65	5.14	9.07	11.86	10.46	10.03	11.86	10.94
F_6	2.74	8.21	5.47	11.53	12.85	12.19	12.12	12.85	12.49
F_7	3.03	8.40	5.71	11.96	13.93	12.94	12.96	13.93	13.44
F_8	2.59	6.89	4.74	11.79	13.41	12.60	12.56	13.41	12.98
F_9	2.90	7.12	5.01	7.87	10.51	9.19	8.43	10.51	9.47
F_{10}	3.38	7.62	5.50	8.41	11.40	9.90	9.25	11.40	10.32
F_{11}	2.87	7.55	5.21	8.27	10.94	9.60	8.51	10.94	9.72
Mean	2.85	7.70		9.79	11.97		10.60	11.97	
	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
M	0.08	0.22		0.14	0.40		0.13	0.37	
F	0.18	NS		0.33	0.94		0.31	0.88	
M X F	0.26	NS		0.47	NS		0.43	NS	

Legend:
DAS: - Days after sowing DAT: - Days after transplanting
M_1:- Direct sowing F_1: - Control (water spray) F_5: - Jeevamrutha @ 5% F_9: - Biochar @ 0.3 %
M_2: - Transplanting of 21th F_2: - Humic Acid @ 0.1% F_6: - Panchagavya @ 5% F_{10}: - *Metarhizium anisopliae* @ 5%
days seedlings F_3: - Salicylic Acid @ 0.01 % F_7: - 19 All (19:19:19) @ 1% F_{11}: - *Beauveria bassiana* @ 5%
NS: - Non significant F_4: - Vermi wash @ 5% F_8: - Bio NPK @ 10%

Table 3: Influence of methods of sowing and foliar application ofnutrientson the number of secondary branches ofchia at 30, 90 days and at harvest

Treatments	Number of secondary branches								
	30 days			90 days			At harvest		
	M_1(DAS)	M_2(DAT)	Mean	M_1(DAS)	M_2(DAT)	Mean	M_1(DAS)	M_2(DAT)	Mean
F_1	0.00	17.40	8.70	11.27	29.40	20.33	13.93	29.40	21.67
F_2	0.00	11.27	5.63	13.27	38.07	25.67	18.27	38.07	28.17
F_3	0.00	18.47	9.23	12.93	37.43	25.18	16.27	37.43	26.85
F_4	0.00	17.60	8.80	13.40	38.13	25.77	21.67	38.13	29.90
F_5	0.00	17.27	8.63	12.33	35.83	24.08	16.07	35.83	25.95
F_6	0.00	19.00	9.50	15.93	40.17	28.05	20.40	40.17	30.28
F_7	0.00	17.40	8.70	18.60	45.40	32.00	24.33	45.40	34.87
F_8	0.00	19.33	9.67	16.47	41.23	28.85	22.00	41.23	31.62
F_9	0.00	16.00	8.00	11.67	29.97	20.82	14.27	29.97	22.12
F_{10}	0.00	14.67	7.33	11.80	33.57	22.68	14.60	33.57	24.08
F_{11}	0.00	17.87	8.93	11.67	31.33	21.50	14.47	31.33	22.90
Mean	0.00	16.93		13.58	36.41		17.84	36.41	
	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
M	0.31	0.87		0.39	1.10		0.36	1.03	
F	0.72	NS		0.91	2.59		0.84	2.41	
M X F	1.01	NS		1.28	NS		1.19	NS	

Legend:
DAS: - Days after sowing DAT: - Days after transplanting
M_1:- Direct sowing F_1: - Control (water spray) F_5: - Jeevamrutha @ 5% F_9: - Biochar @ 0.3 %
M_2: - Transplanting of 21th F_2: - Humic Acid @ 0.1% F_6: - Panchagavya @ 5% F_{10}: - *Metarhizium anisopliae* @ 5%
days seedlings F_3: - Salicylic Acid @ 0.01 % F_7: - 19 All (19:19:19) @ 1% F_{11}: - *Beauveria bassiana* @ 5%
NS: - Non significant F_4: - Vermi wash @ 5% F_8: - Bio NPK @ 10%

Table 4: Influence of methods of sowing and foliar application ofnutrientson the days to 50% flowering and days to spike initiation ofchia

Treatments	Days to spike initiation			Days to 50% flowering		
	M_1(DAS)	M_2(DAT)	Mean	M_1(DAS)	M_2(DAT)	Mean
F_1	48.00	26.00	37.00	55.65	33.32	44.48
F_2	41.33	19.33	30.33	49.66	28.00	38.83
F_3	42.33	20.33	31.33	50.67	29.31	39.99
F_4	41.00	18.00	29.50	49.32	26.32	37.82
F_5	43.33	21.00	32.17	51.99	29.32	40.66
F_6	40.33	17.33	28.83	48.68	26.00	37.34
F_7	39.33	15.33	27.33	47.34	24.00	35.67
F_8	40.00	16.00	28.00	47.65	24.64	36.14
F_9	46.00	24.00	35.00	54.00	33.00	43.50
F_{10}	44.00	22.33	33.17	52.65	31.00	41.82
F_{11}	45.33	23.33	34.33	53.66	31.33	42.50
Mean	42.82	20.27		51.02	28.75	
	S.Em.±	CD @ 5%		S.Em.±	CD @ 5%	
M	0.12	0.33		0.14	0.40	
F	0.27	0.78		0.33	0.93	
M X F	0.39	NS		0.46	NS	

Legend:
DAS: - Days after sowing DAT: - Days after transplanting
M_1:- Direct sowing F_1: - Control (water spray) F_5: - Jeevamrutha @ 5% F_9: - Biochar @ 0.3 %
M_2: - Transplanting of 21th F_2: - Humic Acid @ 0.1% F_6: - Panchagavya @ 5% F_{10}: - *Metarhizium anisopliae* @ 5%
days seedlings F_3: - Salicylic Acid @ 0.01 % F_7: - 19 All (19:19:19) @ 1% F_{11}: - *Beauveria bassiana* @ 5%
NS: - Non significant F_4: - Vermi wash @ 5% F_8: - Bio NPK @ 10%

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