A Study on the Effects of Crop Geometry and Various Organic Nutrient Sources on the Yield and Growth of Chia Latina Salvia L

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Abstract

Chia (Salvia hispanica) is a relatively new crop; hence proper planting technique is crucial for optimal plant development and harvest success. This experiment was carried out at Bangladesh Agricultural University in Mymensingh, Bangladesh, in 2019 and 2020 to determine the best planting techniques for large-scale chia production by analyzing the impact of various planting strategies on the crop's development and yield. A Randomized Complete Block Design (RCBD) with three replications was used to compare the efficacy of three different planting strategies: zero-till, broadcasting, and transplanting. Higher yields were seen with the broadcasting approach compared to the other treatments, suggesting that this strategy is preferable for commercial chia production in Bangladesh.

Keywords: *Crop Geometry, Organic Nutrient, Growth, Latina Salvia L.*

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1. Introduction

Due to its excellent nutritional content and wide range of health benefits, the Chia Latina plant (Salvia L.) has recently surged in favor. Some of the factors contributing to its rising popularity are its high levels of omega-3 fatty acids, antioxidants, and fiber. To get the most out of the Chia Latina crop, careful management is essential. Some of these methods have substantial effects on output and quality, including crop shape and the use of certain nutrients. The goal of this study is to examine the effects of various organic fertiliser sources and crop geometry on the growth and yield of Chia Latina (Salvia L).

Crop geometry includes factors such as plant spacing and field layout. It modifies the quantity of available light, air, and nutrients that plants may utilise. In order to maximize yield and minimize interplant competition, growers of many different crops have turned to innovative crop geometry techniques. However, information on how Chia Latina crop geometry impacts yield is scarce. Understanding how plant density and spacing impact the growth of your Chia Latina crop is essential if you want to get maximum output per acre.[1]

Nutrient availability has a crucial role in shaping plant growth and yield. Compost, animal manure, and biofertilizers are becoming more popular as sustainable alternatives to synthetic fertilizers. Organic nutrients are preferable for plants because they increase soil fertility and foster microbial activity. However, the efficacy of different organic nutrient sources may be affected by their composition, release rates, and other factors. For Chia Latina to be grown in a sustainable and environmentally friendly manner, we must first learn how various organic fertiliser sources influence its development and yield.[2]

Both crop geometry and organic nutrient sources have major effects on the growth and yield of Chia Latina (Salvia L.). This section will address the effects of crop geometry and various organic fertilizer sources on the development and yield of Chia Latina, highlighting the importance of these factors in achieving optimal output and quality.[3]

Crop Geometry:

Crop geometry includes factors such as plant spacing and field layout. The success of a Chia Latina plant depends on its ability to absorb and use light, oxygen, and nutrients. The appropriate crop shape is crucial to maximizing resource efficiency and minimizing plant competition. [4]

Plant density and spacing are two of the most critical factors to consider while cultivating Chia Latina. Overcrowding forces plants to compete for scarce factors like light, fertilizer, and water. This might potentially limit the plant's growth and yield. But if there aren't enough plants per area, some of those resources can go to waste, resulting in fewer yields.

The optimum density of Chia Latina plants per hectare is found to be between 300,000 and 500,000. There should be around 20 to 30 centimeters of spacing between plants in a row. Because of how well light, air, and fertilizer are able to penetrate and distribute in this design, growth and output are maximized..[5]

Organic Nutrient Sources:

Sustainable alternatives to synthetic fertilizers may be made when organic nutrients are employed in Chia Latina cultivation. In addition to providing essential nutrients to plants, they also increase soil fertility, promote beneficial microorganisms, and increase crop yields. The organic nutrients employed have a major impact on Chia Latina's growth and yield. [6]

Compost, animal manure, and biofertilizers are all examples of organic nutrients. There are many useful nutrients and organic materials in compost. It improves soil structure, helps keep nutrients in the ground, and increases the variety of soil microbes. Manure from animals like cows and chickens are an excellent source of nitrogen, phosphorous, and potassium, all of which are essential for plant growth. Plants benefit from increased nutrient uptake and growth thanks to their symbiotic relationships with biofertilizers like rhizobacteria and mycorrhizal fungus.

The efficiency of organic food varies according to its nutritional content, composition, and rate of release. Organic fertilizers having a prolonged time before they begin to drain their nutrients are ideal for maximizing nutrient efficiency. In addition, compared to using organic sources of nourishment, using synthetic fertilisers has a less environmental impact. [7]

2. Literature review

Abubaker, S. (2020) In the axils of their leaves, atop rigid, woody stalks, they produce a single, white star-shaped flower. Fruiting pods or berries, which may vary in size and shape, develop after the flowers. They are born green but may change into one of three other hues. Inside, you can see several white, kidney-shaped seeds. The name "Chilli" in English is often reserved for the hotter kind used for seasoning, although the Spanish word "Chilli" embraces all peppers. C. frutescens grossum, most often known as the Sweet or Bell Pepper, is a popular ingredient. Red or yellow at maturity, the fruit is used more often in its green form as a vegetable.[8]

Fianko, J. R. and Yeboah P.O. (2019) Crop production in a controlled environment is swiftly rising in popularity due to its numerous advantages, particularly for high-value crops. Protection from pests and seasonal challenges, consistent conditions for optimal development and fruit quality, reduced water use, a longer growing season, and off-season cultivation are just some of the many advantages. Capsicum, when grown in greenhouses during the off-season and early spring, is one of the most profitable commercial crops for farmers. There is great potential for exporting it as well.[9]

Berova, M. and Karanatsidis, G. (2018) Capsicum is an off-season crop that may be grown in naturally ventilated polyhouses in India's mild winter climes, providing a considerable possibility for year-round supply. To achieve this, from September 2004 to March 2005, scientists at Dr. Y. S. Parmar University of Horticulture and Forestry in Nauni, Solan, Himachal Pradesh conducted experiments with different growing media, irrigation regimes, fertigation with water-soluble fertilisers, and the use of plastic mulch for greenhouse capsicum production. The randomized block design with three repetitions was used to plant the experiment, and the agro-techniques were separated into seven distinct "modules."[10]

Joyce, D.C. and Reihanytahar, A. (2017) Over the last four decades, India has made great strides in both fertiliser production and application. Furthermore, nitrogen imbalance in soil is negatively impacting soil health and the biochemical components of plant life due to the consistent and imbalanced use of artificial fertilisers in cropping systems. Organic manures, such as Farm Yard Manure (FYM) and vermicompost, may improve soil health and make plant nutrients more available. Organic manures improve the soil's physicochemical properties, making chemical fertilizers more effective. The potential of vermicompost as both a plant food supply and a home for beneficial bacteria has been shown in vermiculture biolaboratories.. [11]

Christo, E.I. and Onuh, M.O. (2016) For these reasons and more, sustainable farming practices such as organic farming, ecological farming, regenerative farming, biodynamic farming, and farming with little external input are gaining popularity in the present decade. The use of organic and other sustainable farming practices is on the rise. Commercial farms, where the emphasis is on growing production, are not likely to be able to maintain such high standards of 100% organic farming, despite the possible benefits to food quality. Even the most diligent organic gardener won't be able to provide their crops with all they require. Integrated soil fertility management practices, such as the judicious use of organic manures, biofertilizers, and chemical fertilisers, are feasible under these circumstances for sustaining agriculture on a commercial and profitable scale.[12]

3. Methodology

The experiment was done from October 2019 to February 2020 at the Bangladesh Agricultural University's Field Laboratory in Mymensingh. Chia seeds were employed in a randomized, completely block design (RCBD) planting experiment. The soil conditions and fertilization treatments were same across all plots. Each plot was 20 square meters in size, and there were three replicates for each of three treatments. There were three methods used: no-till, broadcast, and transplant.

Plant Height

The height of the plants was measured in centimeters using a meter stick. Five random plants were removed to obtain the data. Mean height was reported in centimeters.

Root Length

A meter scale was used to measure the root's whole length, from its base to its tip, in centimeters. Five random plants were removed to obtain the data.

Shoot Length

The height of the shoot was calculated by using a meter stick to measure from the base of the collar to the ground. Five randomly chosen plants had their measurements taken.

Fresh and Dry Weight of Roots

Five plants were randomly selected, their roots, stems, and leaves dissected, and their fresh weights measured using an electric scale in the department laboratory. The roots were then dried in an oven at 80 degrees Celsius for 72 hours. Roots were weighed on an electric scale after drying, and the results were recorded.

Fresh and Dry Weight of Shoots

Five randomly selected plants were transported to the lab, where their roots, stems, and leaves were dissected, and the fresh weight of their shoots was determined using an electric balance. After that, the shoots spent 72 hours drying in an oven at 80 20 C. The weight of the dried shoots was measured using an electric balance.

Starting of Branches at the Nodal Position

When the plants began their first round of branching, we manually counted the number of nodes at which new shoots emerged.

Number of Branches

A simple hand count was used to determine the total number of branches and to categorize them as main, secondary, or tertiary.

Canopy Spread

The diameter of the canopy was measured in centimeters just before harvest..

Inflorescence Length

At the time of harvest, the length (in centimeters) of the main, primary, secondary, and tertiary inflorescence was measured using a simple scale.

Number of Clusters and Spikes in Inflorescence per Plant

At harvest time, a simple hand count was used to determine the total number of clusters and spikes per plant.

Seed and Husk Yields

The grains were sun-dried for a couple of days after harvesting, after which they were taken from the separated panicle. At a final moisture content of 12%, grain weights were collected on a plot-by-plot basis and then converted to (kg/ha). We also took 5 plants at random and counted the number of seeds and husks produced by the main, primary, secondary, and tertiary inflorescence.

Statistical Analysis

Minitab 17 was used for the statistical analysis of the data. The means of the treatments were compared using Tukey's LSD test at the 5% significance level. The Duncan Multiple Range Test (DMRT) was used to identify statistically significant variations in treatment group averages.

4. Results

Measurements of the Plant's Height, Roots, and Shoots

Plant height for chia varied from 72.84 to 120.2 cm, depending on how it was planted. The transplanting approach produced the tallest plant (120.2 cm), whereas the spreading method produced the second-tallest plant (103.42 cm). With no tilling, the plant only reached 72.84 cm in height. The transplanting approach produced the longest roots (28.6 cm), whereas the zero tillage method produced the shortest roots (10.92 cm). The root length of 14.8 centimeters, as shown by the broadcast technique, is around average. Table 1 shows the statistically significant differences in shoot length across the three planting strategies. The length of the shoots on the chia plants varied from 61.92 to 91.6 cm. The transplanting approach produced the tallest shoot (91.6 cm), followed by the broadcasting method (88.62 cm), albeit these differences did not reach statistical significance. The least amount of root development occurred with no tilling (Table 4.1).

Table 4.1: Chia plant height, root length, and shoot length as a function of planting technique

Planting methods	Plant height (cm)	Root length (cm)	Shoot length (cm)
Zerotillage	72.84[b]	10.92[b]	61.92[b]
Broadcasting	103.42[a]	14.8[b]	88.62[a]
Transplanting	120.2[a]	28.6[a]	91.6[a]
LSD(P=0.05)	25.56	7.33	14.65
Level of significance	***	**	**
C.V.(%)	12.34	12.3	10.82

Shooting Weight, Wet and Dry

There was a notable variation in the fresh and dry weight of the shoots across the different planting techniques. The transplanting approach yielded the freshest shoots (50.128 g) and the heaviest shoots (5.234 g) compared to the broadcasting method. Shoot fresh and dry weight was reduced by 28.23% and 19.88% with the broadcasting approach and 86.05% and 81.26% with the zero tillage method, respectively (Table 4.2).

Root Mass, Wet and Dry

Root fresh and dry weight varied significantly between planting techniques. Transplanted roots weighed in at a fresh weight of 20.75 g and a dried weight of 2.11g.Table 4.2 shows a decrease in root fresh and dry weight from the broadcasting technique of 46.80% and 20.38% to the zero tillage approach of 89.98%.

Table 4.2: Root and shoot fresh and dry weight as a function of planting technique

Planting methods	Root fresh weight (g)	Root dry weight (g)	Shoot fresh weight (g)	Shoot dry weight (g)
Zerotillage	2.084^{c}	0.31^{c}	6.992^{c}	0.988^{c}
Broadcasting	11.042^{b}	1.681^{b}	35.974^{b}	4.198^{b}
Transplanting	20.754^{a}	2.11^{a}	50.128^{a}	5.234^{a}
LSD(P=0.05)	3.27	0.41	5.54	0.93
Levelofsignificance	***	***	***	***
CV(%)	13.87	7.53	11.2	6.93

Branches emanate from the node

Variations in planting technique affected branch initiation. In contrast to the early nodal branching seen with the transplanting approach (2.6 nodal locations), zero tillage resulted in a delay in the initiation of branching (4.2 nodal positions; Table 4.3).

Table 4.3: Canopy structure, branching, and branch density in relation to planting technique

Planting method	Starting of branches at the nodal position	Number of branches			Canopy spread (cm)
		Primary	Secondary	Tertiary	
Zerotillage	4.2^{a}	7.6^{b}	7.8^{c}	0.6^{c}	11.4^{b}
Broadcasting	3.2^{b}	10.2^{a}	14.6^{b}	10.0^{b}	18.1^{b}
Transplanting	2.6^{b}	10.0^{a}	28.6^{a}	19.6^{a}	32.4^{a}
LSD(P=0.05)	0.78	1.9	9.85	8.5	12.42
Levelofsignificance	***	*	***	***	***
CV(%)	9.49	10.88	13.56	12.47	15.45

Number of Branches

The planting procedure had an effect on the final branch count. Primary branches were most numerous (10.2) in the broadcasting and transplanting methods and least numerous (7.6) in the zero tillage approach. There was a statistically significant difference in the planting strategies in terms of the number of secondary and tertiary branches. It was found that the transplanting approach resulted in the maximum number of secondary and tertiary branches (28.6 and 19.6, respectively), followed by the broadcasting method (14.6 and 10). Table 3 shows that the zero tillage strategy results in the fewest secondary (7.8) and tertiary (0.6) branches.

Canopy Spread

Chia plant canopies are significantly affected by how they are planted. The transplanting procedure resulted in the widest canopy (32.4 cm). Canopy spread varied from medium (18.1 cm) with the broadcasting strategy to low (11.4 cm) with zero tillage (Table 4.3 and Fig. 4.1).

Length of Inflorescence

Table 4.4 compares the length of the main, primary, secondary, and tertiary inflorescence for each cultivation technique. The results for transplanting are 10.7, 19.6, 16.6, and 10.5 cm, whereas the results for broadcasting are 17.8 cm, 11.44 cm, 12.3 cm, and 6.34 cm.

Table 4.4: Length of inflorescence as affected by planting technique

Planting method	Inflorescence length (cm)			
	Main	Primary	Secondary	Tertiary
Zerotillage	10.84b	9.5b	6.62b	0.3b
Broadcasting	17.8a	11.44b	12.3a	6.34a
Transplanting	10.7b	19.6a	16.6a	10.5a
LSD(P=0.05)	4.23	5.45	5.13	4.67
Levelofsignificance	*	***	***	***
CV(%)	14.3	9.55	18.36	16.88

Inflorescence Cluster Count

The inflorescence cluster count changed depending on how the seeds were planted. The transplanting approach, followed closely by the broadcasting method, produced the maximum number of clusters in all inflorescences save the primary inflorescence. The number of primary, secondary, and tertiary inflorescence clusters was found to be lowest with zero tillage.

Spike Count in Cluster

There was a difference in the total number of spikes per cluster based on planting technique. The number of spikes per cluster was greatest for the transplant procedure among every inflorescence save the primary inflorescence. However, the zero-till approach had the fewest total spikes per cluster in all three stages of inflorescence.

Produces Seeds and Husks

Planting strategy significantly affected seed and husk yields. The seed and husk yields were greatest with the broadcasting approach (795 and 364 kg/ha, respectively), followed by the transplanting method (632 and 310 kg/ha). The seed yield (258 kg/ha) and husk yield (195 kg/ha) were both lowest with minimal tillage.

Historically, taller plants have been reported when direct planting (broadcasting) was used, however in the current research, we discovered no significant difference between the transplanting and broadcasting methods (Table 4.1). The fact that both plants had access to sufficient soil nutrients, light, air, and water may be to blame. There was a statistically significant difference between the treatments in terms of fresh and dry shoot and root weight, number of branches, canopy spread, number of clusters in the inflorescence, and number of spikes per cluster. The transplant procedure outperformed the other therapies. This might be because the transplanting strategy, unlike broadcasting and minimal tillage, eliminated intra-species competition. This ensured that all of the plants were adequately fed.

Yield performance data revealed that broadcasting had the best results, followed by transplanting and finally zero tillage. Since plant density is directly related to yield performance, broadcasting was shown to result in a higher plant density in a 20m2 area than transplanting. Because of the reduced plant density involved in the transplanting approach compared to the broadcasting method, its yield is much lower.

5. Conclusion

Although growth and developmental factors favored the transplanting approach, the data indicated that broadcasting produced the maximum yield. In the end, the findings indicated that commercial Chia production would benefit most from the broadcasting approach.

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