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# Impact of Spacing and Nitrogen Levels on growth and Yield of Chia (*Sylvia hispanica* L.)

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**ABSTRACT: Nitrogen takes part in many physiological and biochemical plant processes and is a structural unit of amino acids, nucleic acids, enzymes and proteins, chlorophyll, and cell wall. Nitrogen is thus universally limiting factor in soil and most important for crops growth and yield, its management in the field level is necessary to obtain high seed yield. Efficient fertilization is necessary in both economic and environmental terms. This minimizes nutrient losses to the environment while producing optimum crop yields. A field experiment was conducted during Kharif season of 2020 at experimental field of National Rice Research Institute (NRRI)-Krishi Vigyan Kendra (KVK), Cuttack to determine the "Impact of spacing and nitrogen levels on growth, yield and economics of chia (*Sylvia hispanica* L.)". The experiment consisted of four, doses of nitrogen (40, 60, 80, 100 kg/ha) and two spacing (50 cm × 20 cm, 60 cm × 20 cm). The experiment was arranged in a statistical design of Randomized Block Design (RBD) with three replications. Report of study indicate that, among different nitrogen levels the application of 100 kg N/ha at 50cm × 20 cm spacing produced significantly superior plant height (151.48cm) and seed yield (1210 kg/ha). The highest seed yield produced by the application of 100 kg N/ha at 50cm × 20 cm spacing is 49.58 % more than control plot (60 kg N/ha at 60 cm × 30 cm spacing). However, the application of 100 kg N/ha at 60 cm × 20 cm was found to be significantly effective in producing maximum number of leaves/Plant (603.20), Dry weight (159 g/plant) and Haulm yield (6146.67 kg/ha).**

**Keywords**: Chia, nitrogen level, spacing, yield, *Sylvia hispanica* L.

## INTRODUCTION

The Chia (*Sylvia hispanica* L.) is an herbaceous plant in the family Lamiaceae and native to mountain areas of Mexico and Guatemala (Ixtaina *et al*., 2008). 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 and are widespread in vegetarian and gluten-free diets. Chia is a plant characterized by low water requirement and well adapted to arid and semiarid regions (Ayerza, 1995). The flour, a byproduct of oil extraction, can be used as human and animal feed supplement is high in fiber and constituents with antioxidant activity (Ayerza and Coates, 1996).

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 edaphoclimatic characteristics of each region. Considering the increasing international demand for Chia, the information on agronomic management and the importance of nitrogen fertilization of crops in soils of Cuttack, Odisha in India is meagre which was an incentive to this work. Objective to evaluate the response of planting geometry and nitrogen fertilization for the growth, development and productivity of chia.

## MATERIALS AND METHODS

The field experiment was conducted during rainy (*kharif*) season of 2020, at the experimental area of the National Rice Research Institute (NRRI)-Krishi Vigyan Kendra (KVK), Cuttack, situated at 20.5º North Latitude and 80º East Longitude, with an average height of 23.5 m above the mean sea level. The average annual rainfall of the zone was 1577 mm received in 66 rainy days. The other distinct climatic features of experimental site has tropical climate, characterized by high temperature and humidity. The soil chemical analysis revealed that soil was sandy loam in texture, acidic in reaction (pH 5.84) medium in organic carbon (0.54%) and potassium (166.88 kg/ha), high in available phosphorus (77.40 kg/ha). The electrical conductivity of the soil was 0.45 dS/m. The experiment was laid out in Randomized Block Design (RBD), having four nitrogen management practices (40, 60, 80, 100 kg/ha) and two spacing (50 cm × 20 cm, 60 cm × 20 cm)with one control plot. There were nine treatments replicated thrice, with plot size of 9 $m^2$ (3m×3m) each. Nine treatments combinations, comprising (*i*) 40 kg N/ha at 50 cm × 20 cm spacing (*ii*) 60 kg N/ha at 50 cm × 20 cm spacing (*iii*) 80 kg N/ha at 50 cm × 20 cm spacing (*iv*) 100 kg N/ha at 50 cm × 20 cm spacing (*v*) 40 kg N/ha at 60 cm × 20 cm spacing (*vi*) 60 kg N/ha at 60 cm × 20 cm spacing (*vii*) 80 kg N/ha at 60 cm × 20 cm spacing (*viii*) 100 kg N/ha at 60 cm × 20 cm spacing (*ix*) 60 kg N/ha at 60 cm × 30 cm spacing (Control).

Crop variety 'CHIAmpion W-83' was seeded manually on second fortnight of July and harvested on first fortnight of November. The crop geometry was maintained as per the spacing prescribed for the particular treatments. The N was applied as specified by the treatments while the P and K fertilizers were applied at40 and 50 kg/ha in all the treatments. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash respectively. Full dose of phosphorus and potassium were applied uniformly as basal to all the plots. Half dose of nitrogen was applied as basal and remaining half dose applied 45 days after sowing.

The observation on growth parameters *viz.* plant height, number of leaves and dry weight were taken at 20, 40, 60, 80 and 100 days after sowing. The data on yield attributing characters *viz.* seed yield, haulm yield and oil content were recorded at harvest.

## RESULTS AND DISCUSSION

Data related to plant height was periodically recorded at 20, 40, 60, 80, and 100 days after sowing and depicted in Table 1. Plant height(cm) were significantly influenced among all treatments at 20, 40 and 60, 80, 100days after sowing and the higher plant height was observed with application of 100 kg N/ha at 50cm × 20 cm spacing that is 18 cm, 45.32 cm, 105.03 cm,151.48 cm and 154.94 cm respectively. This is due to application of more nitrogen, which increased the nitrogen content of the cell sap in the form of protein, amides and aminoacids which resulted in the cell elongation and multiplication which ultimately increased the plant height. The internodal lengths increased with increase in plant population density. This result was in accordance with the data recorded by Inamullah *et al.* (2012). Under high plant density area, plants were competing more for light, this has led to suppression of lateral growth and increased apical dominance. These results are in accordance with the findings of Mary *et al.* (2018). The increase in plant height at higher plant density is probably caused through stem elongation and increase of number of nodes per plant due to mutual shading. The data revealed that nitrogen application exhibited significant effect on the plant growth. Every increase in rate of N application increased the plant height significantly at all the growth stages.

The data on number of green leaves per plant at 20, 40, 60, 80 and 100 days after sowing has influenced due to different treatment combinations are presented in the Table 2. The significantly higher number of leaves was observed at 20, 40, 60, 80 and 100 days after sowing with application of 100 kg N/ha at 60cm × 20 cm spacing (22, 62.07, 144.60,603.20 and 500.60) respectively. At 80 DAS the highest number of leaves was observed with application of 100 kg N/ha at 60cm × 20 cm spacing (603.20) and statistically on par with 100 kg N/ha at 50cm × 20 cm having number of leaves 595.40.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. It was observed that the higher number of leaves were gained in the wider intra row spacing accompanied by higher levels of nitrogenous fertilizer. These results are in conformity with the findings of Shehu *et al.* (2010).

The data pertained to dry matter accumulation at various growth stages (20, 40, 60, 80 and 100 DAS) are depicted in Table 3. At 40, 60, 80and 100 DAS maximum dry matter accumulation was resulted with the application of 100 kg N/ha at 60 cm × 20 cm spacing (4.77 g,17.85 g,159.43 gand147.96 g respectively) and significantly superior to other treatment combinations. The treatment combination 100 kg N/ha at 50 cm × 20 cm spacing (156.19 g) was statistically at par with 100 kg N/ha at 60 cm × 20 cm spacing at 80 DAS. This might be due to the fact that fertilizer induce the growth of the plant through active protein metabolism, transportation of photosynthates and synthesis of nucleic acid and proteins.

**Table 1: Effect of nitrogen levels and different row spacing on plant height of Chia.**

| | | Plant height (cm) | | | | |
|---|---|---|---|---|---|---|
| **S. No.** | **Treatments** | 20 DAS | 40 DAS | 60 DAS | 80 DAS | 100 DAS |
| 1. | 40 kg N/ha at 50 cm × 20 cm spacing | 16.34 | 36.26 | 89.54 | 104.89 | 105.79 |
| 2. | 60 kg N/ha at 50 cm × 20 cm spacing | 16.88 | 40.92 | 95.75 | 132.01 | 132.73 |
| 3. | 80 kg N/ha at 50 cm × 20 cm spacing | 17.49 | 43.65 | 100.60 | 142.41 | 143.19 |
| 4. | 100 kg N/ha at 50 cm × 20 cm spacing | 18.00 | 45.32 | 105.03 | 151.48 | 154.94 |
| 5. | 40 kg N/ha at 60 cm × 20 cm spacing | 16.32 | 32.36 | 86.31 | 95.51 | 96.53 |
| 6. | 60 kg N/ha at 60 cm × 20 cm spacing | 16.61 | 38.24 | 94.74 | 127.55 | 128.33 |
| 7. | 80 kg N/ha at 60 cm × 20 cm spacing | 17.10 | 42.27 | 98.32 | 138.12 | 138.83 |
| 8. | 100 kg N/ha at 60 cm × 20 cm spacing | 17.92 | 44.94 | 102.94 | 148.32 | 149.07 |
| 9. | 60 kg N/ha at 60 cm × 30 cm spacing | 16.18 | 36.79 | 92.80 | 119.41 | 120.15 |
| | SEm(±) | 0.10 | 0.37 | 0.75 | 0.65 | 0.78 |
| | CD (p=0.05) | 0.29 | 1.10 | 2.25 | 1.95 | 2.35 |

**Table 2: Effect of nitrogen levels and different row spacing on number of leaves/plant of Chia.**

| | Number of leaves/plant | | | | | |
|---|---|---|---|---|---|---|
| **S. No.** | **Treatments** | **20 DAS** | **40 DAS** | **60 DAS** | **80 DAS** | **100 DAS** |
| 1. | 40 kg N/ha at 50 cm × 20 cm spacing | 14.87 | 31.47 | 101.13 | 321.53 | 238.53 |
| 2. | 60 kg N/ha at 50 cm × 20 cm spacing | 17.00 | 38.40 | 127.87 | 420.40 | 319.00 |
| 3. | 80 kg N/ha at 50 cm × 20 cm spacing | 17.53 | 53.47 | 129.87 | 487.73 | 385.80 |
| 4. | 100 kg N/ha at 50 cm × 20 cm spacing | 19.93 | 59.20 | 142.40 | 595.40 | 482.53 |
| 5. | 40 kg N/ha at 60 cm × 20 cm spacing | 16.53 | 36.07 | 113.93 | 370.00 | 267.60 |
| 6. | 60 kg N/ha at 60 cm × 20 cm spacing | 17.40 | 47.53 | 125.27 | 436.53 | 332.27 |
| 7. | 80 kg N/ha at 60 cm × 20 cm spacing | 17.80 | 54.80 | 135.27 | 540.27 | 432.07 |
| 8. | 100 kg N/ha at 60 cm × 20 cm spacing | 22.00 | 62.07 | 144.60 | 603.20 | 500.60 |
| 9. | 60 kg N/ha at 60 cm × 30 cm spacing | 18.73 | 57.27 | 138.27 | 565.40 | 459.93 |
| | SEm(±) | 0.32 | 0.68 | 2.58 | 4.52 | 4.77 |
| | CD (p=0.05) | 0.96 | 2.04 | 7.72 | 13.55 | 14.30 |

**Table 3: Effect of nitrogen levels and different row spacing on dry weight of Chia.**

| | Dry Weight (g/plant) | | | | | |
|---|---|---|---|---|---|---|
| **S. No.** | **Treatments** | **20 DAS** | **40 DAS** | **60 DAS** | **80 DAS** | **100 DAS** |
| 1 | 40 kg N/ha at 50 cm × 20 cm spacing | 0.93 | 2.45 | 9.98 | 111.46 | 102.51 |
| 2 | 60 kg N/ha at 50 cm × 20 cm spacing | 1.28 | 2.95 | 12.52 | 132.26 | 121.23 |
| 3 | 80 kg N/ha at 50 cm × 20 cm spacing | 1.09 | 4.08 | 13.73 | 144.89 | 130.08 |
| 4 | 100 kg N/ha at 50 cm × 20 cm spacing | 1.06 | 4.47 | 16.00 | 156.19 | 144.97 |
| 5 | 40 kg N/ha at 60 cm × 20 cm spacing | 1.05 | 2.86 | 11.50 | 119.96 | 107.01 |
| 6 | 60 kg N/ha at 60 cm × 20 cm spacing | 1.42 | 3.66 | 13.02 | 140.71 | 129.67 |
| 7 | 80 kg N/ha at 60 cm × 20 cm spacing | 1.21 | 4.20 | 14.06 | 146.79 | 134.74 |
| 8 | 100 kg N/ha at 60 cm × 20 cm spacing | 1.09 | 4.77 | 17.85 | 159.43 | 147.96 |
| 9 | 60 kg N/ha at 60 cm × 30 cm spacing | 1.13 | 4.28 | 14.88 | 148.26 | 139.83 |
| | SEm(±) | 0.04 | 0.10 | 0.28 | 4.55 | 8.11 |
| | CD (p=0.05) | 0.12 | 0.29 | 0.85 | 13.63 | 24.32 |

**Table 4: Effect of nitrogen levels and different row spacing on yield attributes of Chia.**

| **S. No.** | **Treatments** | **Seed yield (kg/ha)** | **Haulm yield (kg/ha)** | **Harvest index (%)** | **Oil (%)** |
|---|---|---|---|---|---|
| **1** | 40 kg N/ha at 50 cm × 20 cm spacing | 496.67 | 2640.00 | 16.10 | 34.21 |
| **2** | 60 kg N/ha at 50 cm × 20 cm spacing | 820.00 | 4220.00 | 16.29 | 30.47 |
| **3** | 80 kg N/ha at 50 cm × 20 cm spacing | 983.33 | 5836.67 | 14.42 | 28.99 |
| **4** | 100 kg N/ha at 50 cm × 20 cm spacing | 1210.00 | 5918.00 | 16.99 | 27.87 |
| **5** | 40 kg N/ha at 60 cm × 20 cm spacing | 363.33 | 2176.67 | 14.29 | 35.36 |
| **6** | 60 kg N/ha at 60 cm × 20 cm spacing | 756.67 | 3703.33 | 16.97 | 33.56 |
| **7** | 80 kg N/ha at 60 cm × 20 cm spacing | 916.67 | 4903.33 | 15.76 | 30.31 |
| **8** | 100 kg N/ha at 60 cm × 20 cm spacing | 1133.33 | 6146.67 | 15.57 | 28.70 |
| **9** | 60 kg N/ha at 60 cm × 30 cm spacing | 600.00 | 3536.67 | 14.52 | 33.10 |
| | **S.E m(±)** | 32.85 | 166.94 | 1.01 | 0.98 |
| | **CD(p=0.05)** | 98.49 | 500.48 | - | 2.93 |

Hence during the vegetative stage, nitrogen nutrition of the plant to a large extent controls the growth of plant. The higher performance of growth at higher fertility levels with wider spacing could be ascribed to the luxuriant growth of crop as reflected by higher dry matter production. These results are in line with the findings of Barsa *et al*. (2014), Anita and Anna (2010). With increasing plant population, light interception per plant decreases, resulting in a depletion in whole-plant photosynthesis and biomass accumulation. Similar results have been reported by Maruti *et al.* (2018) and Bilalis *et al.* (2017). The different row spacing with levels of nitrogenous fertilizer show significant influence on seed yield.

Application of 100 kg N/ha with narrow spacing (50 cm × 20 cm) brought about higher yield of 1210.00 kg/ha than wider spacing (60 cm × 20 cm).

The treatment combination 100 kg N/ha at 60 cm × 20 cm spacing having seed yield (1133.33 kg/ha) was statistically at par with 100 kg N/ha at 50 cm × 20 cm spacing.

Observation of data on Table 4 clarified that different spacing with nitrogen levels significantly affect the oil yield of chia. The spacing of 60 cm × 20 cm with 40 kg N/ha resulted significantly higher oil content (35.36%) as compared to other treatment combinations.

**A.** Emergence **B.** Two leaves stage

**C.** Flowering stage

The application of 40 kg N/ha at 50 cm row spacing (34 21%) and 60 kg N/ha at 60 cm × 20 cm (33.56%) and 60 cm × 30 cm (33.10%) spacing was statistically at par with 40 kg N/ha at 60 cm × 20 cm spacing. Oil content decreased with the increasing rate of N having closure spacing. These results are in accordance with the findings of Muhammad *et al.* (2012) and Kashani *et al*. (2016).

## CONCLUSION

Optimum seed yield of chia was recorded at 100 kg N/ha at spacing of 50 cm × 20 cm. Comparing the seed yield of chia the application of 100 kg N/ha along with 50 cm row spacing had improved the seed yield of chia by 49.58 % compared to the control plots.

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