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Growth and Yield Analysis using Different Spatial Density in Lactuca *sativa* Production at Cuttington University, Liberia

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Abstract

Using optimum plant spacing is one of the important agronomic practices to maximize the productivity of lettuce. It enhances high yield due to the methods of planting density used. A field experiment was conducted to assess the responses of lettuce to different plant spacing at the Agricultural Research field, at Cuttington University. Three treatments and three levels of intra-row spacing were studied on one type of lettuce variety. These treatments were used to determine the growth analysis of lettuce taking into account all appropriate agronomy practices with equal applications of plant nutrients. The treatments (20cm X 20cm, 20cm X 30cm, and 20cm X 40cm) were arranged in a randomized complete block design (RCBD) with three blocks and three replications in the experiment. The results revealed that marketable and total fresh yield per plant was significantly affected by the main effect of plant spacing. Increasing planting density increased the total fresh leaf yield per unit area of lettuce. The highest yield was obtained using 20cm x 40cm planting density, this shows that by increasing the planting distance, the crop absorbs soil nutrients. Also, 20cm X 30cm planting density slightly performed but could not accumulate a high yield compared to 20cm X 40cm. However, 20cm X 20cm planting density could not obtain the expected yield outcome due to clustering in the total plant population. Reduction in plant spacing lead to a high plant population and such population are usually clustered. Hence, 20cm X 40cm is an optimum plant spacing to grow lettuce.

Keywords: Lettuce, Spatial Density, Growth Yield

1. Introduction

The annual plant lettuce (Lactuca *sativa L.*), a member of the Compositae family, is one of the most essential vegetables consumed by humans. Although the crop is abundant in calcium, iron, and vitamin A, it is often eaten raw and has a high nutritional value. Given its low kilojoule content and high vitamin content, it is frequently recommended to people who are trying to lose weight (Bewuket, G., & Shewaye, H., 2020; & M. M. Maboko, 2007) [3, 9].

Given that in many countries including Liberia, Lettuce is typically eaten cold, raw in salad, sandwiches, hamburgers, and in many other dishes. In other places including China, it is typically eaten cooked, and the use of the stem is as important as the use of the leaf (Anderson *et al*., 2010). Lettuce is a rich source of vitamin K and vitamin A, and a moderate source of folate and iron (Andriolo, J. L 2006) [2]. Contaminated lettuce is often a source of bacterial, viral, and parasitic (Acar *et al*., 2008; Khah & Arvanitoyannis, 2003). Many people can define it in their diets and use it for weight control since it contains few calories and provides calcium iron and vitamin A (M. Gonnella and F. Serio 2002) [10].

The plants largely depend on soil fertility and ideal planting density for their growth nutrition requirements and absorption. A dense population of crops may have limitations in the maximum availability of these vitamins and minerals. It is, therefore, necessary to determine the optimum density of plant population per area unit for obtaining maximum yields (Baloch, A.W 2002). The optimum plant density depends on different factors: plant characteristics, growth period duration, planting time and methods, soil fertility, plant size, available moisture, sunshine, planting pattern, and situation of weeds (Shirtliffe, S.J 2010). Plant spacing is an important production factor in transplanted Lettuce (Gorgy, R.N., 2010). Mohapatra *et al*. reported that plant spacing of 20× 20 cm was better than those of 15 × 15 or 15 × 20 cm under normal soil for lettuce productivity. They further argue that plant height, leaf area index, yield, and yield components of lettuce with plant spacing of 20×20 cm were higher than of 15×15 cm or 15×20 cm.

Lettuce is becoming well-known in Liberia. At first, lettuce was not well known based on the lack of knowledge on methods of production and management. Farmers have been thinking about growth performance considering the spatial density and best agronomy practices to maximize production. Despite the great potential of lettuce production, farmers are still vulnerable to obtaining low yields from their farms due to improper planting densities and arrangement.

In this trial, cultivars of mini-romaine lettuce were characterized to determine their suitability to the growing system in relation to plant spatial arrangements and densities.

2. Materials and Methods

The research was conducted at the Cuttington University, CASD Demonstration Site in Suakoko District, Liberia. The area has a hot and humid climate with temperatures ranging from 65F to 85F and also consists of rainy and dry seasons (MOI, 2007).

A Randomized Complete Block Design with three blocks and three replications including three different planting densities (20cm X 20cm, 20cm X 30cm, and 20cm X 40cm) was used in the experiment. Treatment one contained 50 hills with a planting density of 20cm X 20cm, plus an additional 100 hills for its two replications summing to 150 hills. Treatment 2 contained 33 hills with a planting density of 20cm X 30cm, with another 66 hills for its two replications summing to 99 hills while Treatment 3, 20cm X 40cm consisted of 25 hills and 50 hills for its two replications summing to 75 plants. The sampling selection of the experiment was done using a Randomized selection from each of the plots.

Data was collected on The Number of Leaves, Plant Height, Leaf Weight, and Weight per plot.

The data was subjected to analysis of variance (ANOVA) using Stata software.

Analysis of variance (ANOVA) which includes the computation of the *F* statistics between groups and within groups computed as:

$$F = \frac{MSS_B}{MSS_W}$$

Where F is the test statistics,

MSSB is the Mean sum square between the groups and is calculated as:

$$MSS_B = \frac{\sum_{g\in G}(X-X)^2}{N-K}$$

$\underline{X}$ is the rank value of each respondent

$\overline{X}$ is the mean for each rank

N is the total number of observation

K is the degree of freedom

MSSW is the mean sum of square within groups and will be computed as:

$$MSS_W = \frac{Ng\sum_{g\in G}(X-X)^2}{K-1}$$

Where: Ng is the number of groups

It also included Tables, Charts, graphs and a range of descriptive statistics including means. Pairwise comparison was done using the Tuckey and Bartlett's test for equal variances. Margins sharing a letter in the group label are not significantly different at the 5% level were specified.

Table 1: Analysis of Variance (ANOVA) for Number of leaf with various Trt (20cmx20cm, 20cmX23cm, and 20cmX40cm)

Treatment	*SS*	*MS*	*F*	*Prob > F*
Between groups	14.406	7.203	0.99	0.0863
Within groups	174.64	7.276		
Total	189.05	7.271		
Bartlett's test for equal variances: chi2(2) = 1.3082Prob>chi2 = 0.520				

3. Results

The Bartlett's test for equal variances with Prob > F of 0.0863 shows that the model is statistically significant and that there is a significant difference in the number of leaf produced between the various treatments of 20cmX20cm, 20cmX30cm, and 20cmX40cm. This shows that despite the averages for each treatment varies in number, these means are not statistically equal and that the number of leaf for all treatment perform differently.

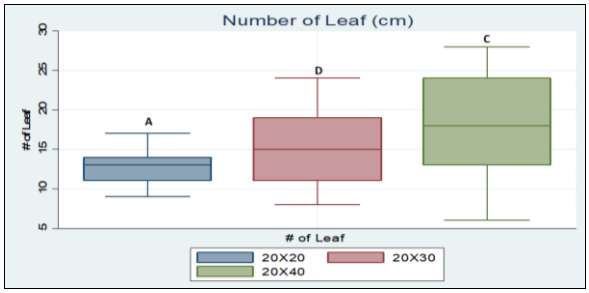

Fig 1: Margins sharing a letter in the group label are not significantly different at the 5% level

Table 2: Analysis of Variance (ANOVA) for plant length with various trt (20cmx20cm, 20cmX23cm, and 20cmX40cm)

Treatment	SS	MS	F	Prob > F
Between groups	12	.67	0.89	0.6069
Within groups	6	.75		
Total	18	1.42		
Bartlett's test for equal variances: chi2(3) = 0.5127 Prob>chi2 = 0.916				

The Tuckey and chi2 tests reveals that the model is statistically insignificant and there is no significant difference in the leaf weight between the various treatment of 20cmX20cm, 20cmX30cm, and 20cmX40cm. This shows that, the means for each treatment do not varies and that these means are statistically equal and the leaf weight for all treatment are equal.

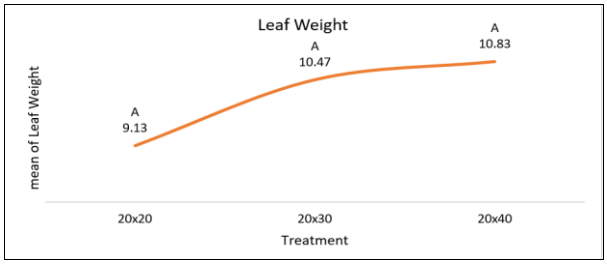

Fig 2: Pairwise comparisons of marginal linear predictions at 5%

The growth performance of plant leaf and plant show similarities but differences at each data point. The results show that there is no significant difference between the three treatments (20cmX20cm, 20cmX30cm, 20cmX40cm). This means that all treatments perform equally and has equal number of leafs showing equitability. The results further revealed that there is a significant difference between treatment 20cmX40cm and all the other treatments. This indicates that there is no significant difference in plant height between treatment 20cmX20cm and 20cmX30cm, and that they have equal heights.

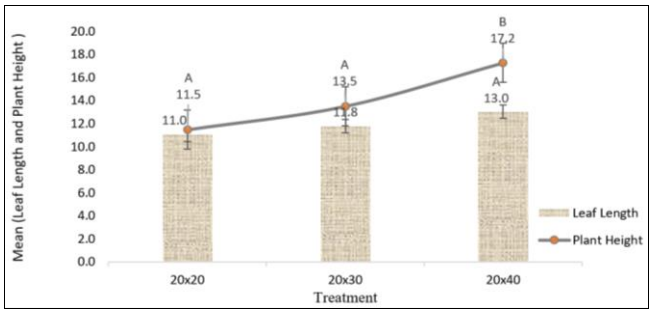

Fig 3: Growth Performance of Leaf Length and Plant Height

The total weight indicating the overall growth performance shows a statistically significant difference in the growth of lettuce for all treatments. The result revealed that the spatial density of 20cmX40cm planting distance is ideal and facilitate high production. This means, the planting distance of 20cmX40cm perform better and has high total output than the rest of the other treatments. The results also show that there is no significant difference between treatment 20cmX20cm and 20cmX30cm and that both treatments performance equally despite the variation in their means.

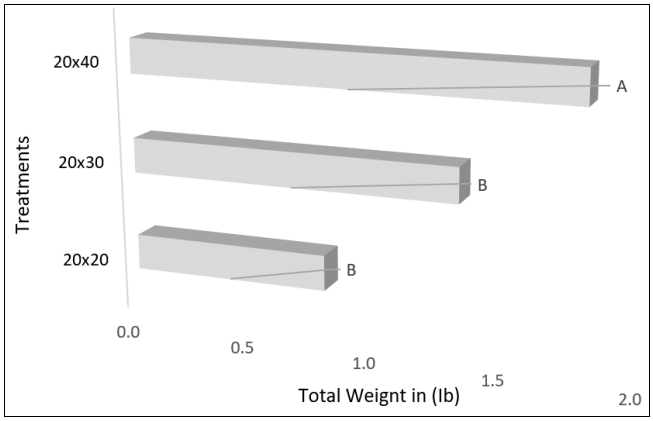

Fig 4: Total Weight (lb)

4. Discussion

From the table, the cultivation of lettuce in this research shows a significant difference. There were three treatments were applied to observe their growth and yield performances. With respect to plant densities, the treatment of spatial density on the growth and yield of lettuce was determined by three different planting densities or spacing (20X20, 20X30, and 20X40). The Results showed that although the various treatments reacted differently to spacing, the closer spacing (20x20 and 20X30) resulted in the low and lowest masses. (Badi *et al*, 2004) [5] stated that the closer spacing produced a significant decrease in leaf area, leaf number, and weight which in turn produced significantly low fresh and dry mass. Because of the increased growth rate, high-density plantings could be harvested later than wider-spaced plants with a consequential shorter growth season. The results showed a tendency of increased leaf fresh and dry mass per unit area as the plant spacing increased (plant population decrease). Lower leaf and yield as compared to 20cmX40cm could be explained by their vigorous growth. The lesser number of plants at the wider spacing contributed to higher leaf fresh and dry mass per unit area as compared to lower spacing.

The results also indicate that the best plant spacing for the leafy lettuce is 20cm x 40cm compared to other spacing used in this trial. The higher number of plants per plot decrease all yield parameters. The more vigorous growth of lettuce with a spatial density of 20X40 dominantly produced as compared to (20X20 and 20X30). It was observed that closely spaced plants grow very slowly with a low yield outcome as compared to wider spaced plants. This is mainly the result of competition for photosynthetic active radiation, and soil nutrients which stimulate growth.

5. Conclusion

To conclude, it was experimented that the production of lettuce with wider spatial density facilitates good growth and optimum yield as compared to shorter densities with dense populations. From the various treatments, 20X40 spatial density was recorded as the best treatment and it facilitated vigor growth and optimum yield. The remaining treatments, 20X20 and 20X30 recorded the lowest and lowest outcomes of the growth analysis respectively.

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