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Effect of planting density on yield of Solanum tuberosum in Cuemal, Lamud, Chachapoyas, Peru, using basic seed 1 and Yungay variety

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ABSTRACT
This work was carried out with the objective of evaluating the effect of different planting densities (0.40 x 0.80, 0.50 x 0.80, and 0.60 x 0.80 meters) on seed production of basic potato 1 of the Yungay variety. For this study, three planting densities of 0.40 x 0.80 m, 0.50 x 0.80 m and 0.60 x 0.80 m were used, which were compared with a control planting density of 0.30 x 0.80 m. The duration of the research was 5 months. The study was conducted in the annex of Cuemal, Chachapoyas, Amazonas Region, between October 2022 and March 2023. The design used in this research work was the Completely Randomized Block Design (CRBD), which was divided into 3 blocks, with a total area of 224 m2 and an experimental area of 196 m2. The observations recorded for data collection were: weight, size and number of tubers per plant, which was done at harvest. Finally, an analysis of variance (ANOVA) was carried out with the Tukey test at 5% significance for the

multiple comparison of means; in this sense, the T3 treatment obtained the best average weight/plant of 1804.92 g, likewise the T3 treatment obtained the best size in the extra and first categories with averages of 9.00 cm and 4.80 cm respectively. In the number of tubers per plant, T3 had the best result with 14.08 tubers/plant, followed by T2 with 13.56 tubers/plant. It is concluded that the T3 treatment with a planting density of 0.60 x 0.80 m presents better results in average weight/plant of 1804.92 g, where the best estimation per hectare of 51545.25 kg of potato/ha was also obtained.

Keywords: potato, yungay, planting density, weight, size

INTRODUCTION

Potato (Solanum tuberosum L.) cultivation is considered the fourth most important food crop in the world, following wheat, rice, and maize (Martín &Mompié, 2015). Studies conducted by Ordinola et al. (2017) inform us that in Peru, potatoes are considered the main crop of the highlands, being the most important crop for small-scale farmers and serving as a significant source of income and nutrition for the high Andean regions located above 3500 meters above sea level.

MIDAGRI (2015) indicates that potatoes are the primary crop in Peru, with a planted area representing 25% of the agricultural GDP. It is considered the cornerstone of nutrition in the Andean regions and is cultivated by over 600,000 production units. Potato cultivation competes with wheat and rice for a place in people's diets.

In his research, Pingus (2019) emphasizes that the agricultural sector is one of the most important factors in the economy. The province of Luya in the Amazonas region hosts various crops from the Andean highlands, among which potato cultivation is the most significant. Being a traditional crop, it has been meeting nutritional and economic needs over time, but it faces limitations in the genetic sector.

Montesdeoca (2005) further highlights the importance of seed quality as a primary input for developing high-quality crops. For potatoes, the use of certified seeds is crucial, as propagation occurs vegetatively through seed tubers. Seeds that do not meet specific physical, sanitary, and physiological requirements result in uneven sprouting, limited plant growth, low yields per area, and the potential spread of diseases and pests, which can be transmitted through low-quality seeds.

Potato production is significantly influenced by planting densities, as they determine the amount of fertilizer to be applied. In general, wider spacing between plants requires less fertilizer, resulting in lower production costs. Under this criterion, it is expected to achieve reduced production costs and high crop yields compared to traditional spacing.

Potato production is decreasing in our region due to farmers' lack of knowledge regarding planting densities. Therefore, the objective of this study was to evaluate the effect of sowing density on the yield of Solanum tuberosum in Cuemal, Lamud, Chachapoyas, Peru, using basic seed 1 and Yungay variety and to provide farmers with a new technique for managing potato planting densities. This technique will help increase productivity, thereby improving their ability to achieve economic benefits and raise their standard of living compared to a traditional management system. Consequently, one of the contributions of this research will be to determine the ideal spacing for the production of basic seed 1 of the Yungay potato variety.

MATERIALES Y MÉTODOS

The study was conducted in the Cuemal annex, located in the district of Lamud, Chachapoyas province, Amazonas department, between October 2022 and March 2023. The geographical coordinates of this location are as follows: southern latitude 6° 7' 51", western longitude 77° 57' 2", with an altitude of 2957 meters above sea level (msnm).

Treatment

The treatments consisted of planting densities of 0.40 x 0.80, 0.50 x 0.80, and 0.60 x 0.80 meters, which were applied to potato cultivation. Additionally, there was a control treatment with a planting density of 0.30 x 0.80 meters for comparison purposes.

Table 1: Planting densities on yield of Solanum tuberosum in Cuemal, Lamud, Chachapoyas, Peru, using basic seed 1 and Yungay variety

Treatments	Key Words	Number Of Repetitions
0.30 x 0.80 m	To	3
0.40 x 0.80 m	T1	3
0.50 x 0.80 m	T2	3
0.60 x 0.80 m	T3	3

Variables to be recorded

In accordance with the set objectives, the following evaluations were carried out:

Weight, size, and number of tubers per plant

Ten potato plants were randomly selected from the experimental area, and all tubers were weighed. The data were expressed in Kg/plant, size, and number of tubers.

Yield per hectare

The weight of the tubers was obtained from the net experimental area and then converted to hectares. For the statistical analysis, four treatments with three repetitions were used, and a Completely Randomized Block Design (CRBD) was employed. Analysis of Variance (ANOVA) was conducted to determine if there was an effect of the treatments. Subsequently, a Tukey test (0.95) was performed to assess the differences between treatments. The R Statistical Program was utilized for this analysis.

RESULTS AND DISCUSSION

Weight of tubers per plant and Assessment of tonnage per hectare estimation

In Figure 1, it can be observed that the treatment that yielded the highest tuber weight per plant was T3, with an average of 1804.92 grams, while the control (T0) only had an average of 1250.30 grams. These results were converted into tn/ha, and we obtained 51.5 tn/ha in T3, surpassing T2 and T1, with 48.6 and 39.9 tn/ha, respectively (Figure 2). Likewise, Correa (2013) obtained potato tuber yields (31 and 42 tn/ha) with planting densities of 0.40 x 0.80 m and 0.50 x 0.80 m, respectively, while the control with 0.30 x 0.80 m did not perform well, yielding 25.7 tn/ha. Basic seed 1, due to its varietal purity, ensures high production yields and outperforms Garzón (2014), who reported 17.68 tn/ha. Furthermore, it informs us that low potato yields in Peru and other countries are due to the limited use of certified seed and the selection of contaminated tubers from previous harvests. On the other hand, Pérez (2003) conducted research on planting densities in the Yanahuanca district, using different potato varieties, including the Yungay variety. The conclusion regarding yield was that the best averages were obtained when planting densities of 0.40 x 0.80 m were used, with 47.50 tn/ha. On the other hand, the lowest averages for this variable were obtained when planting densities of 0.50 x 0.80 m were used, with 44.77 tn/ha.

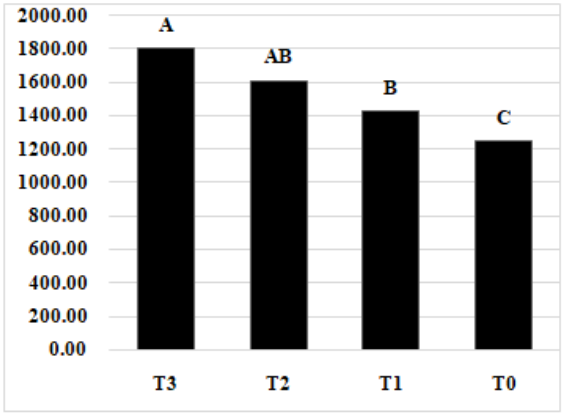

Fig. 1: Tuber Weight per Plant

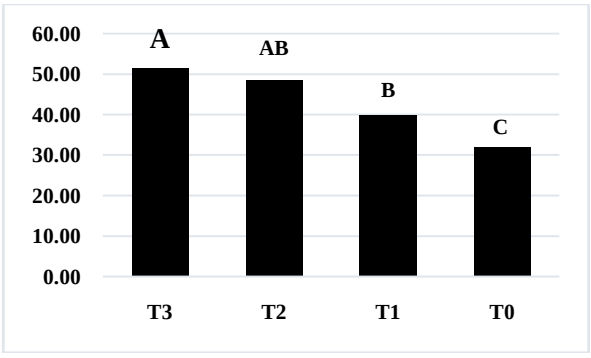

Fig. 2: Estimation tn/ha

Size of tubers: extra, first, second, and third.

In Figure 3, the results regarding the size of extra tubers indicate that there is a statistical difference at both significance levels. Treatment 3 achieved the largest size, measuring 9.00 cm, surpassing the control, which had the smallest size at 6.20 cm. Similarly, there is a statistical difference in both significance levels for the size of the first-class tubers. Treatment 3 achieved the largest size at 5.80 cm, surpassing the control, which had the smallest size at 5.20 cm. Furthermore, the results for the size of second-class tubers indicate no statistical significance between treatments at both significance levels. Treatment 3 achieved the largest size at 4.50 cm, surpassing the control, which had the smallest size at 4.00 cm. Finally, the size of third-class tubers also indicates no statistical significance between treatments at both significance levels. Treatment 3 achieved the largest size at 3.80 cm, surpassing the control, which had the smallest size at 3.60 cm.

The results show that treatment 3 (spacing of 0.60 x 0.80) yielded the best average results of 9.00 cm, 5.80 cm, 4.50 cm, and 3.80 cm for extra, first-class, second-class, and third-class tubers, respectively. These results were surpassed by Vega (2010), who reported 13.05 cm, 6.68 cm, and 4.88 cm for first, second, and third-class tubers, respectively. However, they are similar to what López (2010) reported, with 7.75 cm, 5.95 cm, and 4.425 cm for first, second, and third-class tubers, respectively. This indicates the effect of planting density, as mentioned by the National Institute of Agricultural Research (INIA, 1995), where the planting distance depends on the potato variety, growing conditions, and the desired tuber size. Higher crop density results in smaller harvested tubers. Generally, a higher stem density is recommended for seed potato production compared to potato consumption production.

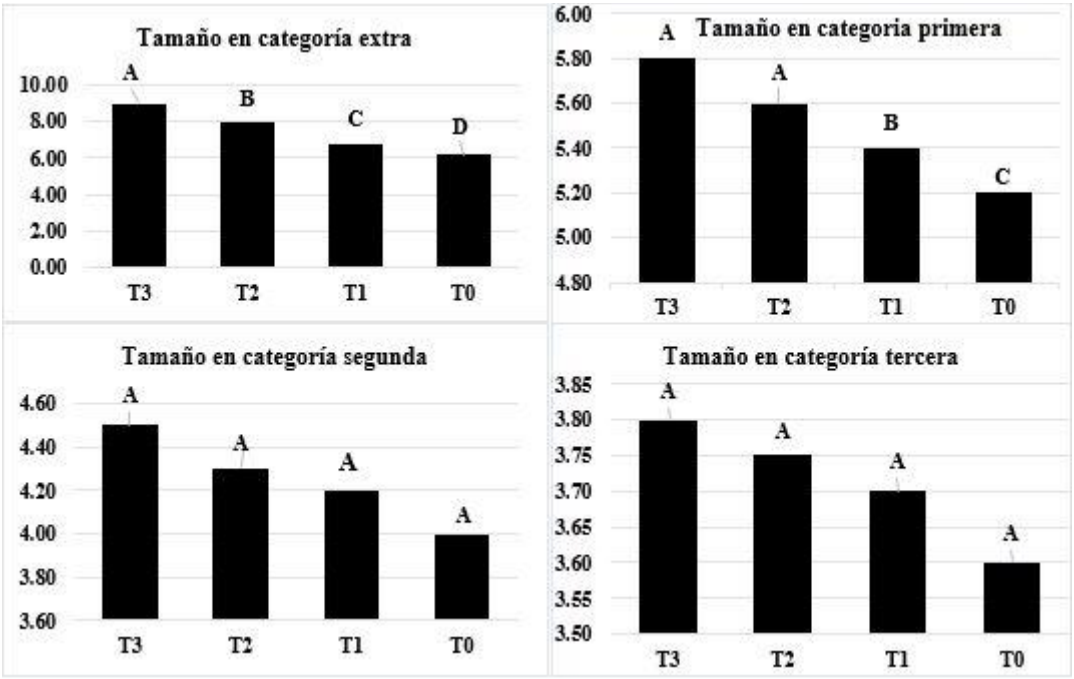

Fig. 3: Size of Tubers: Extra, First, Second, and Third

Number of Tubers per Plant

In Figure 4, on the evaluation of the number of tubers per plant, it is observed that the treatment with the highest number of tubers per plant is treatment 3 with an average of 14.08 tubers, while treatments 2 and 1 achieved averages of 13.56 and 12.89 tubers per plant, respectively. The results indicate that there are statistically significant differences in the number of tubers. Treatment T3 (Spacing of 0.60 x 0.80) reported 14.08 tubers. These results differ from those reported by Rubio Moreno (2015), who obtained a mean of 11.92 tubers per plant. In the study conducted by Garzón (2014), an average of 35 tubers/plant was obtained at a spacing of 0.30 m x 1.10 m, and the total average was 47 tubers/plant. The results obtained differ from previous research due to the treatments, variety, planting altitude, and crop conditions. Additionally, Realpe (2010) states that they achieved a production of 24.48 tubers per plant in the San Pedro de Huaca canton at 2950 masl, under suitable conditions for this variety, which include a temperature between 13 and 18°C, an altitude between 2750 and 2950 masl, and 600 to 700 mm of precipitation. In the conducted research, a higher tuber production was achieved. This is attributed to the use of basic seed, as this tuber has not yet degenerated and maintains quality characteristics. Consequently, the average production was higher compared to what was reported by previous authors.

Tuberization of the plant is influenced by the number of shoots on the mother tuber, which affects the number of stems and, consequently, the number of tubers per plant (Inostroza, 2009). On the other hand, Pozo (2001)

pointed out that some clones or varieties tend to produce a greater number of tubers due to their genotype, and Sands et al. (1979) mentioned that the plant can form as many tubers as its genetics can express under specific management conditions.

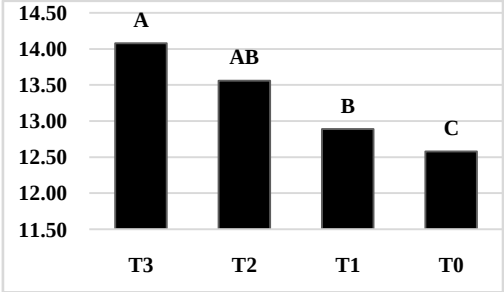

Fig. 4: Number of tubers per plant.

CONCLUSIONS

The best results in terms of weight, size, number of tubers per plant, and estimated yield in tn/ha were achieved with treatments T3 (0.80 x 0.60 m spacing) and T2 (0.80 x 0.50 m spacing).Treatments T3 and T2 demonstrated superior performance in terms of weight per plant, with values of 1804.92 g and 1609.20 g, respectively. Additionally, fruit size per plant measured 9.0 cm and 4.80 cm for treatments T3 and T2, respectively. Regarding yield per hectare, values of 51.5 tn/ha and 48.6 tn/ha were obtained for treatments T3 and T2, respectively. These results suggest a more exhaustive study of the effect of the planting densities considered in this trial to improve the yield of Solanum tuberosum in Cuemal, Lamud, Chachapoyas, Peru, using basic seed 1 and the Yungay variety.

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