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## PRODUCTIVITY OF ONION VARIETIES IN THREE PLANTING DISTANCES

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### ABSTRACT

The objective of the research was to evaluate the productivity of onion varieties in planting distances. The research work is carried out in the Campus of the Universidad Nacional de Concepción of the Facultad de Ciencias Agrarias, Department of Concepción, Paraguay. The experimental design was randomized complete blocks, with a 2x3 plot subdivided and five repetitions, the main plot being the varieties (Premiun, Baia periforme) and the secondary plot in the distances between plants (10, 15, 20 cm). The data were tested in the analysis of the variance and the averages compared in the Tukey test at 5% probability. In the variables of diameter and height of bulbs, significant effects were demonstrated in the distances of plantation; The average weight of the bulbs has differences in the two factors. For the variable productivity of the commercial bulbs of the onion, there was also a great significant difference in the sense of the variety of the behaviours in the way of differentiating in the three distances of transplantation; Finally, the productivity of each of the bulbs is important in both factors. It is concluded that the use of the Baia periforme variety and a distance of 10 cm between plants has a better performance on the productivity of onion bulbs.

### INTRODUCTION

Onion (*Allium cepa* L.) belongs to the family Alliaceae genus *Allium* (Griffiths et al. 2002), and it is a cross-pollinated, herbaceous and biennial crop. It is one of the most important cool season vegetable crops. It ranks second among all vegetables in economic importance after tomatoes in the world (Malloret al., 2011).

The onion is a vegetable of great importance within the Paraguayan family diet. Regarding the commercialised volume, it occupies the second place, after the tomato. Daily consumption in the country is around 100 tons per day and approximately 80% is of foreign origin, mainly from Argentina and Brazil. The national production presents a seasonal supply concentrated between

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October to December (MAG, 2017).

Concerning the spatial arrangement in the crop, the recommended planting densities vary from 15 to 20 cm between plants and 25 to 30 cm between rows, this allows a better establishment of the plant in the field and also facilitates management (MAG, 2017).

The onion is produced in excellent conditions in our country, and its quality is superior to that of the imported ones, but the bad practice in the establishment of the crop and also the harvest usually causes problems for its conservation, which in turn leads to problems for marketing. The national onion is more profitable in the kitchen because it has more flavour and less film around the bulb but due to the low rate of technical assistance and poor cultivation practices, it is often not possible to compete with the introduction of other countries.

Research conducted by Santos et al. (2000) in Maringa, Brazil with the variety Texas Grano with distances between plants of 5; 10 and 15 cm, and between rows of 30 cm, show that the shorter distances provided reductions in the weight of bulbs, but increases in yields. In the same way, Candía and Enciso (2006) studying the effect of different distances between plants (10; 15; 20 and 25 cm) in the performance of the Bala Periforme variety; in San Lorenzo, they obtained the highest yields with a distance of 10 cm between plants.

Resende et al. (2005) verified the increase in onion productivity of Texas Grain 502 PRR cultivation, as the spacing between rows and between plants was reduced, being the highest productivity obtained with the spacing of 0.15 m between rows and 0.10 m between plants. Thus, spacing is an important factor for the production of onion since it affects both bulb yield and quality. Planting density greatly influences quality, texture, taste and yield of onion even within a particular variety (Saud et al. 2013). The main objective of this research work is to evaluate the productivity of two varieties of onion in three planting distances.

## 2. MATERIALS AND METHODS

The research work was carried out in the Campus of the Universidad Nacional de Concepción, Facultad de Ciencias Agrarias, located at 2.5 km from the city of Concepción on the route V Bernardino Caballero. The climate of the area is characterized by an average temperature of 26 °C and 14 °C with maximum temperatures that can reach 45 °C in summer and minimum temperatures of up to 4 °C in winter, with slight incidences of frost (Dirección de Meteorología e Hidrología de la Dirección de Aeronautica Civil del Paraguay, 2018).

The soil of the experimental area according to the analysis carried out, presents the following chemical and physical characteristics in the depth of 0 - 0.20 cm: pH (H<sub>2</sub>O) 5.67; organic matter (Walkley Black): 1.67%; Ca + 2, Mg + 2 and K +: 5.06, 1.27 and 0.19 cmol / LS, respectively; P (Mehlich) and S: 28.94 and 11.73 mg / LS, respectively; Al + 3: 0.05; CIC: 9.71 cmol / LS; V: 67.21%. The texture of the soil is sandy loam (CETAPAR, 2018).

The experimental design to distribute the treatments was randomized complete blocks, with subdivided 2x3 plot and five replications, being the main plot the varieties (Premium, Baia periforme) and the secondary plot are the distances between plants (10, 15, 20 cm) (Table 1), thus totaling 30 experimental units (EU) by combining the factors.

The production of seedlings was carried out in seedbeds, where cow manure was applied at a dose of 4 kg/m. The sowing was carried out in the month of March 2018, in a row in furrows with a depth of 1 cm separated every 10 cm. The cultural care in this stage consisted of manual irrigation with a 10-liter watering can and weed elimination.

The preparation of soil for the transplant in a final place consisted of soil removal with the treadmill machine with two passes. Subsequently, the 1 m wide and 20 cm high planks were prepared, where bovine manure was applied at a dose of 5 kg/m. Each plank was separated by a 50 cm walkway. The seedlings were transplanted bare root to the final place, in the month of May 2018 when they presented 5 mm in diameter of the stem at ground level and 15 cm in height.

The culture was kept free of weeds by hand carpids. Coverage fertilizations were carried out 25 and 55 days after the transplant, applying a total of 130 kg/ha of Nitrogen, 90 kg ha<sup>-1</sup> of Phosphorus and 170 kg/ha of Potassium. In the first application 30% of the total fertilizer dose was used, and the remaining one (70%) in the second application. The experimental plot received sprinkler irrigation.

The harvest was carried out in October of 2018, when more than 80% of the plants showed signs of maturation, characterized by yellowing of the leaves and bending of the neck. The curing was carried out for three days by exposure to the sun and seven days in the shade, in a place with good ventilation. For the evaluation, 20 plants were selected at random from the central row of each experimental unit. The diameter of bulbs: was measured, at the time of harvest, with a vernier diameter corresponding to the part of the most widened bulb or the area of the equator; This measurement was made at 116 days. The results were expressed in millimeters.

Height of bulbs: was measured, at the time of harvest, with a vernier the height of bulbs. The results were expressed in millimeters.

Average weight of bulbs: at the time of harvest the bulbs were weighed using precision scales to obtain the average weight of bulbs per treatment. The results were expressed in grams.

Commercial productivity: obtained using the total mass of the bulbs with a diameter greater than 35 mm, the results expressed in tn/ha.

Productivity in each size type of bulbs: The typeification of the bulbs was made according to the regulations of the Ministério da Agricultura Pecuária e Abastecimento (Brazil, 1995) based on the transversal diameter, in: type 1 (bulbs with diameter greater than 35 mm) ; Type 2 (bulbs with diameter between 35 and 50 mm); Type 3 (bulbs with diameter between 50 and 75 mm); Type 4 (bulbs with diameter between 75 and 90 mm); Type 5 (bulbs with diameter greater than 90 mm).

The data obtained were subjected to the Analysis of Variance and Fisher's Test; subsequently, the means were compared by the Tukey test at 5% and, where significant differences were found, regression analysis was performed. Statistical analyzes were performed using the statistical package Agro-Estat 7.7 (Barbosa and Maldonado, 2015).

### **3. RESULTS AND DISCUSSIONS**

#### **3.1 Diameter, height and Mean weight**

In Table 2, we can see the results obtained for the growth and productivity variables in the onion crop, according to the analysis of variance, no significant statistical differences were detected for the variables diameter and height of the bulb, for the factor A (Varieties). On the other hand, when analyzing the behaviour of the mean weight variable, if highly significant statistical differences were found. Regarding factor B (distance between plants), it was observed that highly significant differences were found in all the variables, confirming a significant influence of the planting distance between plants in the diameter, height and average weight of the onion. The values for the coefficients of variation in the variables diameter (5.61%), height (5.02%) and average weight (8.35%) were normal for the conditions in which the experiment was developed (Pimentel and Garcia, 2002).

When analyzing the variable average weight for the factor A in table 2, the results obtained show us that the Baia periforme variety obtained a higher average weight compared to the Premiun variety, with a

difference of 41, 22 g, probably due to the fact that the soil and climate conditions of the area are more suitable for the aforementioned variety, the values are lower than those obtained by Enciso and Ríos, (2008), who in their experiment on onion varieties on different planting densities, obtained 180, 63 gr in average weight of bulb with the variety baia periforme. They are also inferior to results obtained by Chimborazo, (2015), who using the Red Nice variety with a distance of 0.15 m between plants, obtained means of 165 gr for average weight of bulb.

The value of the average weight obtained for the baia periforme variety in the experiment is within the range reported by Resende (2006), who states that the Baía Periforme variety presents a firmness and uniformity of the bulbs, is quite productive, reaching a weighted average of 150 to 180 grams. The variation of the distance between plants significantly affected the onion with respect to diameter, height and average weight. It is observed that as the distance between plants increases, also increases the diameter, the height and the average weight of bulbs, this behavior may be due to the fact that at a greater distance of sowing between plants, there is less competition for light, nutrients, etc., which promotes the growth of the plant. This behavior in the bulb diameter is similar to that reported by Candia and Enciso, (2006), who found that at greater planting distances, greater diameters were obtained in the onion bulb.

When we analysed the diameter of the bulbs, we found that with 20 cm between plants 65.38 mm is obtained compared to 46.46 mm obtained with the distance of 10 cm. These data are slightly different from those obtained by Chimborazo, (2015), which with a distance of 0.15 m between plants on average obtained bulb diameters of 165 gr. The highest heights of the bulb are obtained with a distance of 20 cm between plants, observing a difference of 19.97 mm with respect to those plants that were sown 10 cm away. The average weight of the bulbs was higher at distances of 20 cm between plants, reaching values of 159.71 g, compared to those that were sown at 10 cm, which only obtained 132.19 g.

The values obtained in average weight in the present experiment are superior to those reported by Enciso and Ríos, (2008), who obtained average weights of bulbs of 152.99 g with 12 cm of distance between plants. They indicate that they did not find significant statistical differences in the height and average weight of bulbs with the different plant spacings, which differs with the results of the present experiment.

### 3.2 Commercial productivity

The analysis of variance for the commercial productivity variable of onion bulbs per hectare showed highly significant statistical differences, according to the interaction between the AxB factors (Varieties x Distance between plants).

The regression analysis performed for the interaction between the AxB factors is presented in figure 1, in which the behavior of the productivity of onion varieties can be observed in function of the variation of the distance between plants. The lines for both the Premiun and Baia periforme variety show similar behavior. When analyzing the equation of the line for the Premiun variety, we have a decreasing linear behavior, where for every 0.96 cm increase of the distance between plants there is a decrease of one unit of onion productivity in tons per hectare. To say that the highest productivity was obtained with the smallest distances between plants, this same interaction is observed in the linear equation for the Baia periforme variety, where for each increase of 1.86 cm in the distance between plants there is a decrease of one unit in the productivity of bulbs in tn/ha. The coefficient of determination  $R^2$  for these equations was 0.99 (Premiun) and 0.96 (Baia periforme), which indicates in both cases a good fit of the model used (Báez et al. 2002).

These results are similar to those obtained by Candia and Enciso, (2006), which found the same behavior in the productivity of bulbs with variation of the distance between plants, where the highest total production of bulbs corresponded to the lowest spacing between plants; similar results found by Baier et al. (2009) that verified an increase of 28 tnha<sup>-1</sup> when the population increased from 500 to 100,000 plants per hectare. The highest productivity was found in the Baia periforme variety with 44.47 tn/ha with 10 cm between plants, a result similar to that obtained by Candía and Enciso, (2006), who obtained an average yield of 25.99 tn/ha with the distance between plants of 10 cm.

### **3.3 Productivity in each size type of bulbs**

The analysis of variance made for the interaction between the AxB factors for each bulb type of the Premium variety showed the existence of significant statistical differences. In Figure 2, the linear regression analysis is presented where it can be noted that the productivity performance of the Premium variety as a function of the planting distance is similar for each of the four types of bulbs studied, obtaining the highest yields with the smallest planting distance.

This model is repeated in each kind of bulb, the generated lines show a decreasing tendency, where the productivity decreases as the distance of sowing increases. In addition we noticed that the bulbs belonging to type 3 obtained the highest productivity, when analyzing the equation of type 3, we obtain that with the increase of 0.44 cm in the distancing of sowing, the productivity decrease in one unit is produced.

The productivity for type 2 bulbs was also higher with the shorter planting distance, being below the type 3 bulbs in terms of tons per hectare produced. The lowest productivity was obtained with type 4 bulbs.

The coefficient of determination  $R^2$  for the equations of each kind of bulb was 0.99 (Type 3); 0.99 (Type 2); 0.99 (Type 1) and 0.99 (Type 4), which indicates in all cases a good fit of the model used.

The analysis of variance carried out for the interaction between the AxB factors for each commercial bulb type of the Baia periforme variety showed the existence of significant statistical differences. In Figure 3, the linear regression analysis is presented where it can be observed that the productivity performance of the Baia periforme variety as a function of the planting distance is similar for each of the four types of bulbs studied.

The bulbs belonging to the commercial type 2 were the ones that obtained a higher productivity, when analyzing the equation generated for this type, it is deduced that with each increase of 0.86 cm in the distance of sowing, the decrease of the productivity in a unit, the smallest planting distance was the one that gave the best yields, in this way it is affirmed that smaller planting distances provide higher yields, especially in bulbs of commercial type 2 for the variety studied.

For the other kinds of bulbs the same decreasing tendency of the productivity with the increase of the distance of sowing is observed, the bulbs of the type 4 were those that granted the lower productivities coinciding with the results obtained for the Premium variety.

The coefficient of determination  $R^2$  for the equations of each kind of bulb was 0.96 (Type 2); 0.96 (Type 3); 0.96 (Type 1) and 0.96 (Type 4), which indicates in all cases a good fit of the model used. These results differ from those reported by Zarza et al. (2015), in their essay on morphological and qualitative characteristics of onion varieties in three transplant seasons, in which they observed that the Baia periforme variety does not have good productivity of commercial bulbs. This may be due to the sowing season, environmental conditions and densities used in the study.

The classification of the bulbs according to the size type and another indicator of the quality of production achieved. According to Souza and Resende (2002), the national consumer market prefers medium-sized bulbs, with an average weight of 80 to 100 g and a cross-sectional diameter, varying between 40 and 80 mm.

#### 4. Conclusions

The Baia periforme variety was superior to the Premium about diameter, average weight, the productivity of bulbs and productivity of bulbs in each type, except at the height of bulbs, regardless of the density between plants.

The increase of the density between plants reduces the diameter, the height, however increase the economic productivity.

The use of the Baia Periforme variety and a distance of 20 cm between plants is recommended.

#### Conflict of interests

The authors declare no conflict of interest.

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## TABLES

Table 1: Treatments utilized in the experiment

| Principal plot | Secondary plot  | Description  |
|----------------|-----------------|--------------|
| Varieties      | Plants distance |              |
| Premium        | 10              | Premium + 10 |
|                | 15              | Premium + 15 |
|                | 20              | Premium + 20 |
| Baia Periforme | 10              | Baia + 10    |
|                | 15              | Baia + 15    |
|                | 20              | Baia + 20    |

Table 2: Average values of diameter, height and Mean weight of different onion varieties influenced by different distances

| Factor          | Description    | Diameter (mm) | Height (mm) | Mean weight (g) |
|-----------------|----------------|---------------|-------------|-----------------|
| Varieties       | Premium        | 53,06         | 57,48       | 126,17 b        |
|                 | Baia periforme | 55,41         | 56,50       | 167,39 a        |
|                 |                |               |             |                 |
| Plants distance | (cm.pl)        |               |             |                 |
|                 | 10             | 46,46 c       | 49,28 b     | 132,19 b        |
|                 | 15             | 50,87 b       | 52,43 b     | 148,45 a        |
|                 | 20             | 65,38 a       | 69,25 a     | 159,71 a        |
| CV %            |                | 5,61          | 5,02        | 8,35            |

(ns): Not significantly by Fisher test at 5% of significance; CV: coefficient of variation; (\*\*) Significant by Fisher test at 1% of significance.

## FIGURES

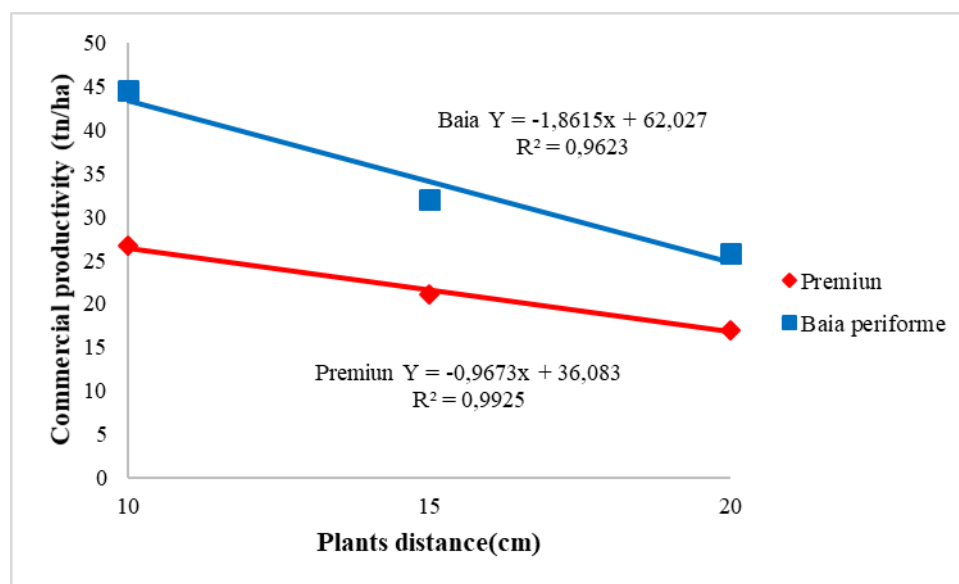


Figure 1: Productivity of commercial bulbs of two onion varieties influenced with different distances between plants

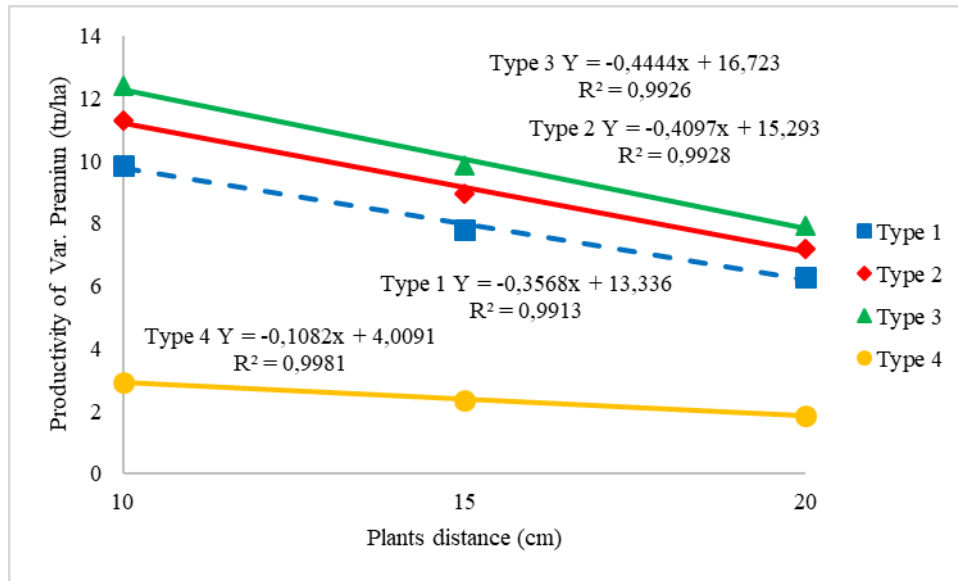


Figure 2. Productivity of the Premium variety within each type of onion bulbs, depending on the distance

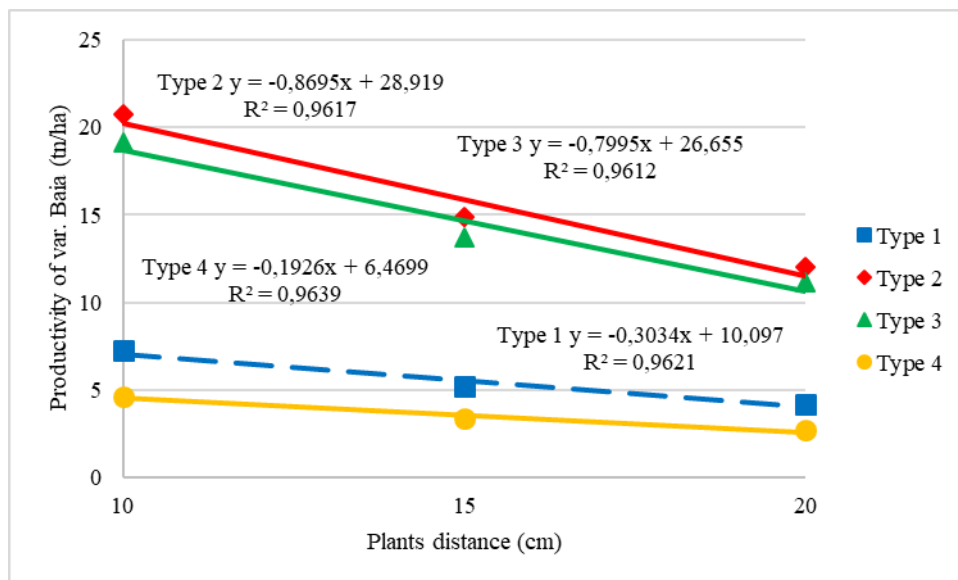


Figure 3: Productivity of the Baia periforme variety within each type of onion bulbs, depending on the distance



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