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# Produção de cebolinha em função da densidade de plantio

**Chives production according to planting density**

**Producción de cebollino según densidad de siembra**

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**Resumo**

Na busca pela otimização da produção, a utilização da densidade de plantas ideal é de fundamental importância. Por isto, objetivou-se com este trabalho avaliar o efeito da densidade de plantio na produção de cebolinha, variando o espaçamento entre covas e o número de plantas por cova. O delineamento experimental utilizado foi em blocos casualizados, com doze tratamentos, no esquema fatorial 4x3, sendo quatro espaçamentos entre covas (0,05; 0,08; 0,11 e 0,14 m) e três números de plantas por cova (2, 3 e 4 plantas por cova), com quatro repetições. Foram avaliados o número de folhas, altura de planta, diâmetro de folhas, massa fresca e seca da parte aérea (g planta$^{-1}$) e produtividade (t ha$^{-1}$). Foi observado que com maior número de plantas por cova, há redução na produção por planta, no entanto, a produtividade é maior. Quanto menor o espaçamento, maior a produtividade de cebolinha. Portanto, pode-se recomendar a maior densidade de plantio para a produção de cebolinha e o uso de três ou quatro plantas por cova.

**Palavras-chave:** *Allium fistulosum*; Espaçamento; Plantas por cova; Folhas.

**Abstract**

In the search for optimization of production, the use of the ideal plant density is of fundamental importance. So, the objective of this research was to evaluate the effect of planting densities on chive production, varying the spacing between holes and the number of plants per hole. The experimental design was a randomized block design, with twelve treatments in the 4 x 3 factorial scheme, with four spacings between holes (0.05, 0.08, 0.11 and 0.14 m) and three numbers of plants per hole (2, 3 and 4 plants per hole), with four replicates. Leaf number, plant height, leaf diameter, fresh and dry shoot weight (g plant$^{-1}$) and yield (t ha$^{-1}$) were evaluated. It was observed that with a greater number of plants per hole, there is reduction in the production per plant, however, the yield is higher. The smaller the spacing, the greater the yield of chives. So it is possible to recommend the higher plant density for chive production, and the use of three or four plants per hole.

**Keywords:** *Allium fistulosum*; Spacing; Plants per hole; Leaves.

**Resumen**

En la búsqueda de la optimización de la producción, el uso de la densidad ideal de la planta es de fundamental importancia. Por esta razón, el objetivo de este trabajo fue evaluar el efecto de la densidad de siembra en la producción de cebollino, variando el espacio entre los pozos y el número de plantas por hoyo. El diseño experimental utilizado fue en bloques aleatorizados, con doce tratamientos, en un esquema factorial 4x3, con cuatro espacios entre agujeros (0.05; 0.08; 0.11 y 0.14 m) y tres números de plantas por hoyo (2, 3 y 4 plantas por hoyo), con cuatro repeticiones. Se evaluó el número de hojas, altura de la planta, diámetro de la hoja, masa fresca y seca de la parte aérea (g planta$^{-1}$) y productividad (t ha$^{-1}$). Se observó que con un mayor número de plantas por hoyo, hay una reducción en la producción por planta, sin embargo, la productividad es mayor. Cuanto más pequeño es el espacio, mayor es la productividad de las cebolletas. Por lo tanto, se puede recomendar la mayor densidad de siembra para la producción de cebollino y el uso de tres o cuatro plantas por hoyo.

**Palabras clave:** *Allium fistulosum*; Espaciamiento; Plantas por hoyo; Hojas.

## 1. Introduction

Chive (*Allium fistulosum*) is a vegetable belonging to the Alliaceae family of considerable value and importance in several regions of Brazil. The plants resemble the onion, but they are characterized by the intense tillering, forming a clump. It has an important social role because it is cultivated in small areas by family farmers (Filgueira, 2012).

For optimization of production, one of the crucial points to be considered is the spatial organization of plants, which can be manipulated through changes in planting density. However, for most crops, increasing yield by increasing number of plants per unit area has certain limits, considering that in higher plant density there is an increase in competition between plants, and the individual development of each plant is impaired (Corrêa et al., 2014, Takahashi & Cardoso, 2014; Tavares et al., 2016; Candian et al., 2017). In addition, greater plant densities optimize the ability to suppression of culture on weeds, due to early soil shading, interfering negatively in the early growth and development of these (Carvalho & Guzzo, 2008; Candian et al., 2017).

In the cultivation of chives, Filgueira (2012) recommends the spacing of 0.25m between rows and 0.15m between plants. However, no studies were found in the Brazilian literature about the influence of plant density on chives yield, but there are some reports in other vegetables (Menezes Júnior & Vieira Neto, 2012; Pôrto et al., 2012; Corrêa et al., 2014; Takahashi & Cardoso, 2014; Tavares et al., 2016). In these studies, generally, with increase in plant density there is reduction in the production of each plant individually and increase of the yield, until a certain limit, when the reduction in the production per plant by the intraspecific competition exceeds the increase of the production by the greater number of plants by unit of area.

An alternative to increase planting density without changing the already established spacing would be to use two or more plants per hole, maximizing the use of planted area. This is already common in chives without, however, there being studies that prove to be a beneficial or harmful practice. For this reason, the objective of this study was to evaluate the effect of planting densities on chive production, varying the spacing between holes and the number of plants per hole.

## 2. Methodology

It is a field research that aims to reach new knowledge for a society as stated Pereira et al. (2018). The field experiment was conducted at the São Manuel Experimental Farm, located in the municipality of São Manuel-SP, belonging to School of Agriculture (FCA), São Paulo State University (UNESP), Botucatu campus (22° 46' south latitude, 48° 34' west longitude and 740m altitude). The local climate is Cfa (Temperate Mesothermal), according to Köppen's international classification (Cunha & Martins, 2009).

The soil of the experimental area was classified as typic Distrophic Red Latosol, sandy texture. Chemical analysis (0-20 cm), before the installation of the experiment were: pH ($CaCl_2$) = 5.2; organic matter = 12 g $dm^{-3}$; P = 46 mg $dm^{-3}$; H + Al = 16 $mmol_c$ $dm^{-3}$; K = 2.2 $mmol_c$ $dm^{-3}$; Ca = 16 $mmol_c$ $dm^{-3}$; Mg = 4 $mmol_c$ $dm^{-3}$; sum of bases (SB) = 22 $mmol_c$ $dm^{-3}$; CEC = 38 $mmol_c$ $dm^{-3}$ and base saturation (V%) = 58%. The fertilization was based on the recommendation of Trani et al. (1997) for the state of São Paulo, applying 40 kg $ha^{-1}$ of N, 240 kg $ha^{-1}$ of $P_2O_5$, 120 kg $ha^{-1}$ of $K_2O$ and 40 t $ha^{-1}$ of organic compost.

The cultivar Ibirité (Horticeres®) was used and sowing was carried out on April 13, 2016 in polypropylene trays with 200 cells containing commercial substrate for vegetables. The transplant was performed on May 18, 2016 in beds of 1.20 m wide, 60.0 m in length and 0.2 m in height.

Twelve treatments were evaluated, with four replications in the randomized block design. The twelve treatments were the result of the factorial 4 x 4, with four spacing between holes (0.05, 0.08, 0.11 and 0.14 m) and three plant numbers per hole (2, 3 and 4 plants per hole). The experimental plot consisted of four lines with six holes in each, and only plants of the four central holes were evaluated in each plot. The line spacing was 0.20 m.

Micro-sprinkler irrigation was used (about 3mm per day). Cover fertilization was made according to the recommendations of Trani et al. (1997), providing 120 kg $ha^{-1}$ of N, in the form of ammonium sulphate, and 60 kg $ha^{-1}$ of $K_2O$, in the form of potassium chloride, divided in three applications at 15, 30 and 45 days after transplantation, applying 1/3 of the recommended dose on each date.

The harvest ($1^{st}$ cut) was carried out on July 6, 2016, cutting the aerial part (shoot) of the plants close to the ground. A new harvest ($2^{nd}$ cut), after regrowth of plants, was performed on August 1, 2016. The number of leaves, plant height, leaf diameter, fresh and dry shoot weight (g $plant^{-1}$) and yield (t $ha^{-1}$) were evaluated. To obtain the dry weight of the

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shoot, the samples were packed in paper bags and then placed in a forced circulation air oven at 65ºC until reaching a constant weight.

Data were submitted to analysis of variance and Tukey test ($p<0.05$) was used to compare the number of plants per hole and regression analysis for the spacing between holes, using the statistical software Sisvar (Ferreira, 2011).

## 3. Results and Discussion

### First harvest

According to analysis of variance, the interaction between the factor spacing between holes and number of plants per hole was not significant for all characteristics evaluated in the first harvest, allowing the discussion of each factor individually. The treatments with two plants per hole had higher number of leaves per plant compared to four plants (Table 1).

It was observed that with two plants per hole the plants presented lower height, with an average value of 37.1 cm (Table 1). According to Medeiros (2015), the greater competition for light in the holes with greater number of plants contributes to the plants achieving higher heights. Also Takahashi & Cardoso (2014) observed that for some mini lettuce cultivars higher planting densities resulted in plants with higher height, probably due to the greater competition for light. However, spacing between holes did not affect the height of the plants, showing that competition within the hole by light is greater than between plants of different holes. The values observed were higher than those reported by Zárate et al. (2006), which obtained an average value of 24 cm in intercropped chives with arugula. Of course these values depend on several factors, such as cultivar used and environmental conditions, in addition to the time the plants remain in the field until harvest.

**Table 1.** Number of leaves (NL), plant height (PH), leaf diameter (LD), fresh (FW) and dry matter weight (DW) of shoot as a function of the number of plants per hole (NPH) in chives in the first and in the second harvests.

| | | | | | |
|---|---|---|---|---|---|
| | | | **First harvest** | | |
| **NPH** | **NL** | **PH** (cm) | **LD** (mm) | **FW** (g plant$^{-1}$) | **DW** (g plant$^{-1}$) |
| 2 | 4.2 a[1] | 37.1 b | 12.3 a | 12.6 a | 0.9 a |
| 3 | 3.9 ab | 41.3 a | 12.5 a | 12.5 a | 0.9 a |
| 4 | 3.6 b | 39.9 a | 10.9 b | 8.6 b | 0.6 b |
| CV(%) | 11.6 | 7.9 | 9.1 | 22.5 | 22.8 |
| | | | **Second harvest** | | |
| 2 | 5.4 a | 39.5 b | 15.4 a | 21.8 a | 1.7 a |
| 3 | 4.8 ab | 42.9 a | 14.9 a | 19.5 a | 1.5 a |
| 4 | 4.2 b | 43.1 a | 14.4 a | 14.8 b | 1.1 b |
| CV(%) | 15.4 | 6.6 | 11.9 | 16.5 | 17.0 |

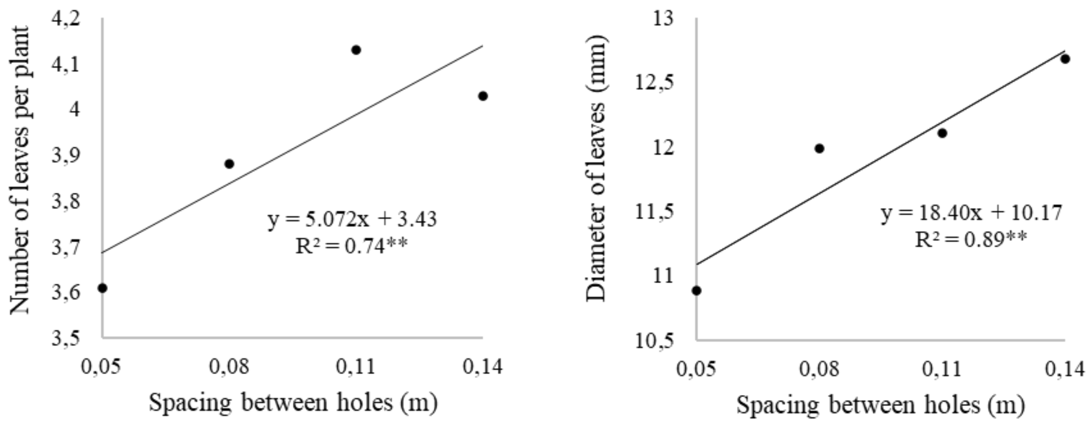
[1]Averages followed by same letters, in columns, for each harvest, do not differ from each other, Tukey test at 5% probability. Source: authors.

Treatments with two and three plants per hole resulted in larger fresh and dry shoot weight per plant than with four plants per hole (Table 1), showing that greater competition in the hole reduces the production of each plant individually. This correlation between yield per plant and density was also observed in other vegetables (Pôrto et al., 2012; Corrêa et al., 2014; Takahashi & Cardoso, 2014; Tavares et al., 2016; Candian et al., 2017). The explanation may be related to the increase of the shading between plants and consequently decrease of the photosynthetic index. There is also greater competition as the number of plants per hole increases, especially for nutrients (Azpilicueta et al., 2012), since the fertilization was the same for all treatments.

However, the spacing between holes did not affect the production of fresh and dry weight per plant, showing that the competition between the plants of different holes takes longer to start, compared to the competition between plants in each hole, which may explain the absence of observed differences in production per plant as a function of spacing. Competition in the hole is greater than between holes, because in each hole plants compete since the beginning of the cycle for space, light and nutrients, while the reduction in spacing causes competition for space and light only after the plants have already developed and begin to occupy, in part, the same space, which occurs only after half the cycle of the plants.

The treatments with two and three plants per hole showed larger leaf diameter averages, with 12.3 mm and 12.5 mm, respectively, in relation to four plants (Table 1), that is, a greater number of plants in the hole increases the competition between them, reducing the diameter. Also, increased plant density, with decreased hole spacing, resulted in a reduction in leaf diameter (Figure 1). Although significant, the increase was only 1.6 mm when comparing the diameters estimated in the lowest (0.05 m) and the largest (0.14 m) spacing studied, which were 11.1 mm and 12.7 mm, respectively.

**Figure 1.** Number of leaves per plant and mean diameter of leaves as a function of the spacing between holes in the first harvest.




Source: authors

The higher effect of the number of plants per hole in the number of leaves, plant height and diameter compared to spacing between holes is due to intraspecific competition since the beginning of the cycle. At the beginning of the cycle, plants develop without competition between holes (Simões et al., 2016), while within holes the competition occurs during all cycle, since seed germination.

According to Tavares et al. (2016), this effect may be related to the increase of the shading between plants in the hole that causes a decrease in the photosynthetic index, resulting in a smaller amount of leaves. On the other hand, it was observed a linear increase in the number of leaves per plant, the larger the spacing between holes (Figure 1).

These results indicate that smaller populations provide less competition between plants, tending to have more leaves per plant. According to Menezes Júnior & Vieira Neto

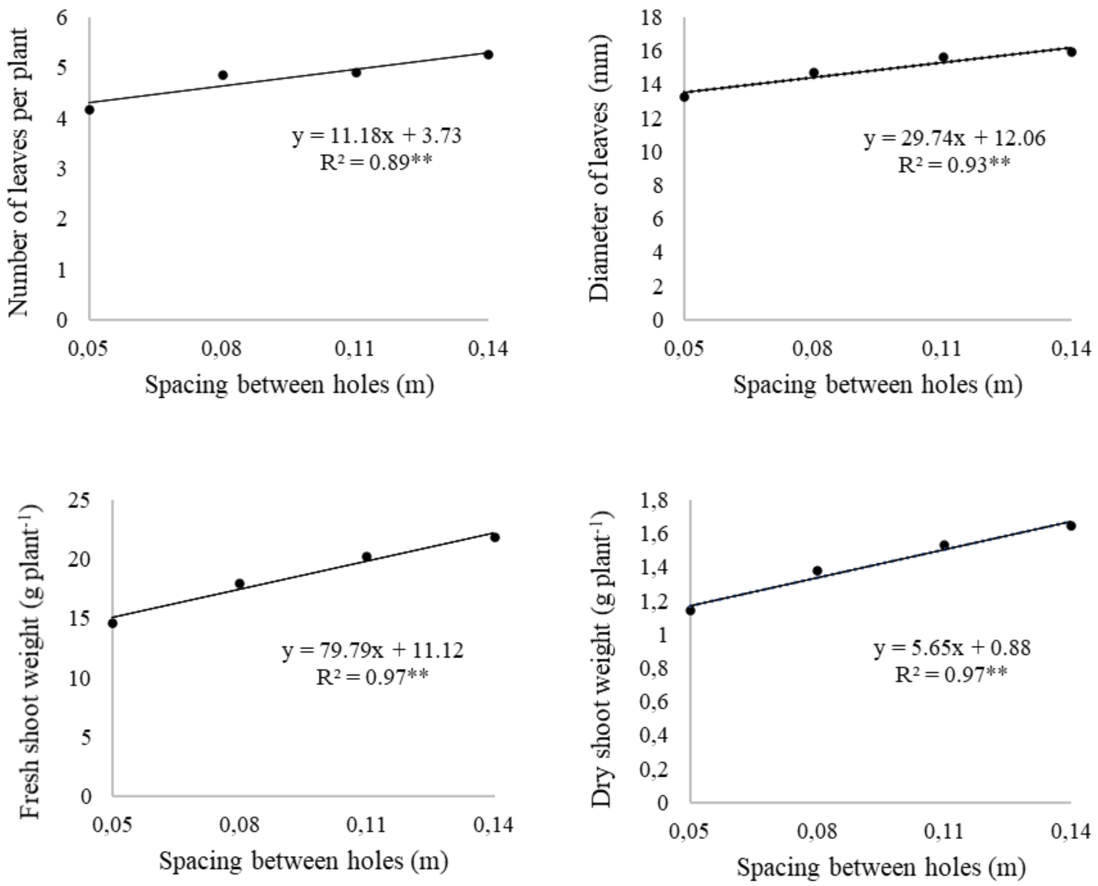
(2012), plants conducted under higher population densities reduce their growth and development speed, due to the fact that there is greater competition for light, water and nutrients.

**Second harvest**

There was also no significant interaction between the factors spacing and number of plants per hole for all characteristics evaluated in the second harvest.

The treatment with two plants per hole presented higher number of leaves per plant than the other treatments, with an average of 5.4 leaves per plant (Table 1). It was observed, also, linear increase in the number of leaves per plant, the greater the spacing between holes (Figure 2).

**Figure 2.** Number of leaves per plant, mean diameter of leaves, fresh and dry shoot weight per plant as a function of the spacing between holes in the second harvest.




Source: authors.

For an increase of 1 cm in the spacing occurred an increase of 0.11 leaves per plant, with 4.2 and 5.3 leaves per plant, in the lowest (0.05 m) and in the largest (0.14 m) spacing studied, respectively, that is, increase of 1.1 leaf per plant.

It was observed that with two plants per hole the plants presented lower height, with a mean value of 39.49 cm (Table 1). However, spacing between holes did not affect plant height. For the leaf diameter, no statistical difference was observed among the number of plants per hole. However, the larger the spacing, the larger the leaf diameter (Figure 2). Although significant, the increase was only 2.7 mm when comparing the diameters estimated in the lowest (0.05 m) and the largest (0.14 m) spacing studied.

The highest average fresh and dry shoot weight per plant were obtained in the treatments with two and three plants per hole (Table 1), evidencing that the greater competition in the hole with four plants can lead to a reduction in the production per plant. Unlike the first harvest, hole spacing affected linearly the production of fresh and dry weight per plant (Figure 2).

**Total yield**

With three and four plants per hole, yields (first and second harvest and total yield) were higher than treatments with two plants per hole (Table 2), that is, the higher number of plants per hole more than compensates the loss of weight of each individual plant.

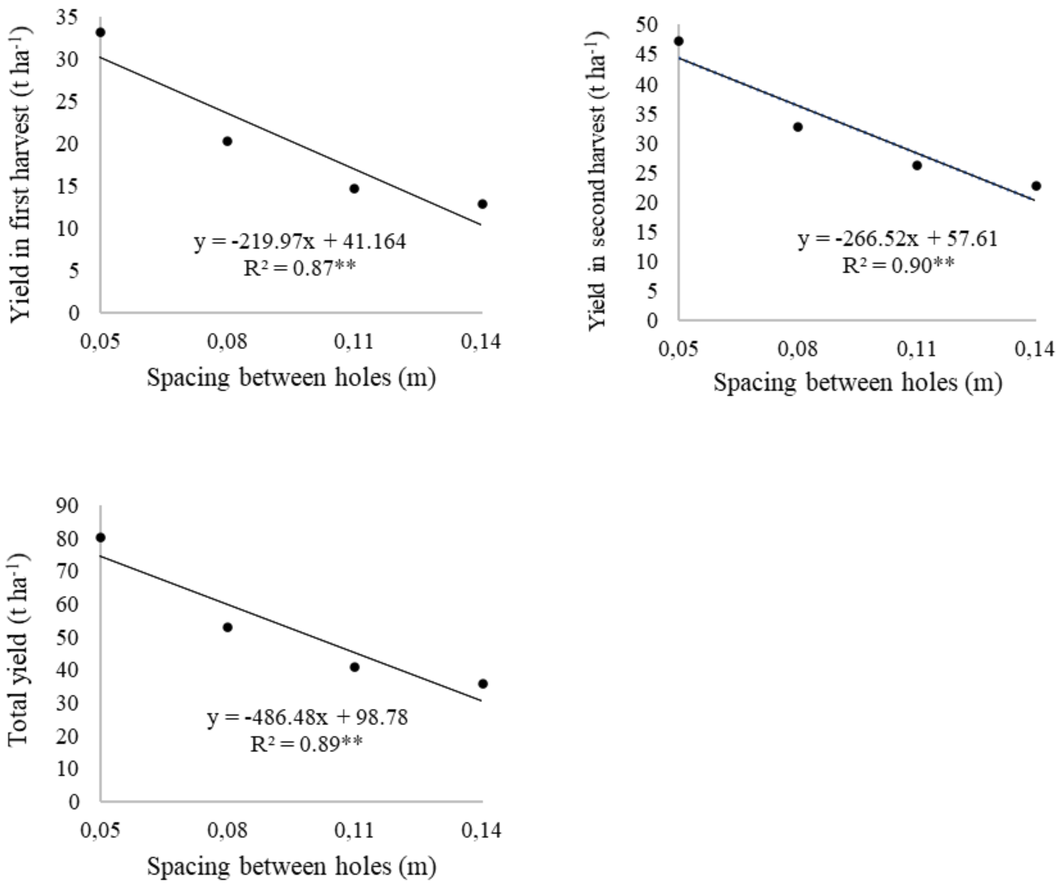
**Table 2.** Yield of chives as a function of the number of plants per hole.

| | Yield (t ha$^{-1}$) | | |
|---|---|---|---|
| Number of plants per hole | **First harvest** | **Second harvest** | **Total** |
| 2 | 15.3 b[1] | 25.3 b | 40.59 b |
| 3 | 22.9 a | 34.4 a | 57.36 a |
| 4 | 22.6 a | 37.2 a | 59.74 a |
| CV(%) | 21.6 | 17.4 | 18.42 |

[1]Averages followed by same letters, in columns, do not differ from each other, Tukey test at 5% probability. Source: authors.

Therefore, although intra-specific competition provided reduction in production (fresh weight) per plant, this reduction was small compared to the increase provided by the higher number of plants per hole. However, the smaller the spacing, the higher the yield (Figure 3), showing that the highest plant density studied resulted the highest yield.

**Figure 3.** Chive yield as a function of spacing between holes in the first and second harvest, and total yield**.**




Source: authors.

The estimated total yield varied from 30.7 to 74.5 t ha$^{-1}$ from the largest (0.14 cm) to the smallest (0.05 cm) spacing between holes, with an increase of 4.9 t ha$^{-1}$ in total yield for every 1 cm less in spacing. In addition to the greater number of plants per unit area, increasing plant population also helps reduce losses caused by weed (Carvalho & Guzzo, 2008), increases soil protection, efficiency in the use of available resources and, consequently, increases yield.

All plants, regardless of treatment, received the same cultural treatments after transplanting, including fertilization (before planting and in coverage). Favorable conditions after transplanting, especially fertilization and sanity, favored the full development of plants, without restrition.

The increase in yield with an increase in the number of plants per hole and/or per area is possible up to a certain limit, when the losses of production per plant due to the greater competition are not compensated by the greater number of plants per area. However, researchers do not always reach this limit, with linear yield increases within the studied plant density range, as observed in this research and in others with different species of vegetables (Pôrto et al., 2012; Takahashi & Cardoso, 2014; Tavares et al., 2016; Candian et al., 2017). Therefore, we can say that the results of this research agree with majority of authors who also studied plant density in different vegetable species.

## 4. Final Considerations

It is possible to recommend the higher plant density for chive production, and the use of three or four plants per hole.

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