

# Agroeconomic performance of the chive (*Allium fistulosum*) under different seedlings management methods

## ABSTRACT

Due to the importance of chive cultivation and the lack of information in the preparation of the seedlings, the objective of this study was to evaluate the influence of number of tillers, and the presence or absence of cutting of shoots in the preparation of seedlings, on the agroeconomic performance of chives. The experimental design was a randomized block design, with three replications, in a split plot scheme, with the treatments in the plots applied following a  $2 \times 4$  factorial with two levels for the cut factor (i.e., with and without leaf cuttings) and four levels for the "number of tillers" factor (2, 3, 4, and 5 tillers per seedling). Harvesting was done twice, at 73 and 100 days after planting (DAP). At each harvesting period, the plant length, fresh mass, dry matter mass, and diameter of each tiller were evaluated. In addition, the mass of fresh and dry matter of plants with and without commercial pattern and the number of tillers per plant were noted. In order to evaluate economic performance, the following indicators were used: gross income, net income, return rate, and profitability index. The highest mass values of the fresh and commercial dry matter of chives are obtained with five tillers per seedling, and the aerial part of the tillers are neither cut at the time of planting or at the time of harvesting at 100 DAP. Considering the economic indicators, it is recommended to harvest at 100 DAP, use two tillers per seedlings, and not cutshoots at the time of planting.

**Keywords:** Asexual propagation, number of tillers, cut in the aerial part.

## 1. INTRODUCTION

The edaphoclimatic characteristics required by chives (*Allium fistulosum* L.) make it possible to grow them widely in Brazil. One can find the cultivation of this important condiment, which is commonly used in Brazilian cuisine, even in vegetable gardens, and in pots and pans in large cities. Espírito Santo, the municipality of Santa Maria de Jetibá produces 218.04 tons, or almost 80% of the total production in Brazil [1]. CEAGESP is the 75<sup>th</sup> most commercialized product. In 2016, 2606 tons of chives were marketed in the Capital Warehouse [2].

Chive cultivation is usually carried out by family farmers, which for many of them, is their only source of income. Chive is a perennial plant, with cylindrical and fistulous leaves, 0.30-0.50 m tall, dark green in color, and produces a small conical bulb, surrounded by a pinkish film, with tillering and clump formation [3].

The propagation using seeds is carried out by sowing them and then transplanting the seedlings to the definitive seedbed [3]. In asexual propagation, part of the adult plant is used for the formation of molt. In this case, the clumps are plucked and these are divided into tillers that will serve as seedlings [4]. In the tiller we find the lower basal part of the leaf sheaths, which make up the pseudocaule, the stem, and the roots, which characterizes this material as having great potential for propagation [5]. Despite the availability of seeds in the market for sexual propagation, asexual propagation is more widely used.

Because of its great capacity for regrowth, several **ha are possible**. However, based on the requirements of the market, one could also harvest the plant at once, obtaining a product of superior quality [3]. In order to exploit a more demanding market, and to improve cultivation techniques, many farmers have **give** preference to the commercialization of the entire plant instead of cutting the plant several times.

Thus, at the time of propagation, instead of the producers using seedlings whose aerial parts were cut and discarded, they began to use the entire plant, dividing the clump into tassels. However, there is still a lack of information about the efficiency of this method, their performance when compared to conventional methods (i.e., with aerial parts cut), and when a combination of these methods were used. Further, information on the ideal number of tillers to ensure the best performance of the crop is also lacking.

From the physiological point of view, it is worth mentioning that the maintenance of the entire leaf or part of it implies that in the initial phase, the seedlings will favor rooting, probably by the synthesis of carbohydrates through photosynthesis and the supply of auxins and other substances that are important in the process of root formation, stimulating the activity of exchange and cell differentiation [6].

The ideal number of tillers for the composition of each seedling should also be carefully considered, because with less number of tillers there will be a reduction of lateral buds for the formation of clumps, while many tillers will favor intracompetition, damaging the final quality of the clump. According to [7] competition between the tillers for their growth factors such as water, light, and space, increases, causing the death of the new tillers.

The ideal harvest time in the onion crop should be well defined by the farmer. If the harvest is carried out in advance, the productivity will be lower than the potential of the plant, if it is of late form can occur damages in the quality of the product and reduction of the commercial value. Therefore, the harvest point should be defined when the plant has expressed the maximum productive potential and the lowest number of leaves without commercial standards.

In view of the above, the purpose of this study was to evaluate the agro-economic performance of chive as a function of the number of tillers and the presence or absence of shoot cutting in the preparation of the seedlings.

## 2. MATERIAL AND METHODS / EXPERIMENTAL DETAILS / METHODOLOGY

The experiment was carried out from May to September 2016 at the "Sítio Krause" property located in the municipality of Santa Maria de Jetibá-ES, Central Serrana Region of Espírito Santo, located at latitude 20°01'S, longitude 40°42'W, at an altitude of 663 m in relation to the level of the sea. The municipality receives rainfall of approximately 1290 mm annually and experiences tropical climate with dry winter season (Köppen classification), with average temperature of 20.6 °C.

The experimental design was a randomized block design, with three replications, in a split plot scheme, with the treatments in the plots, resulting from a 2 × 4 factorial, with two levels for the factor "cut" (with and without cutting of the aerial part of the seedlings) and four levels for the factor "number of tillers" (2, 3, 4, and 5 tillers per seedling) (Table 1). The treatments in the subplots were composed of two evaluation periods (I - when the plants in which the aerial part was cut did not present themselves at the point of harvest - 73 days after planting (DAP)); II - when the plants in which the aerial parts were cut presented themselves - 100 DAP).

**Table 1** - Treatments used in the experiment including the presence and absence of aerial part cut, number of tillers, and different harvesting times.

| Treatments | Presence or absence of cutting of shoots | Number of tillers | Days to harvest |
|------------|------------------------------------------|-------------------|-----------------|
| 1          | cut                                      | 2                 | 73              |
| 2          | cut                                      | 3                 | 73              |
| 3          | cut                                      | 4                 | 73              |
| 4          | cut                                      | 5                 | 73              |
| 5          | no cut                                   | 2                 | 73              |
| 6          | no cut                                   | 3                 | 73              |
| 7          | no cut                                   | 4                 | 73              |

|    |        |   |     |
|----|--------|---|-----|
| 8  | no cut | 5 | 73  |
| 9  | cut    | 2 | 100 |
| 10 | cut    | 3 | 100 |
| 11 | cut    | 4 | 100 |
| 12 | cut    | 5 | 100 |
| 13 | no cut | 2 | 100 |
| 14 | no cut | 3 | 100 |
| 15 | no cut | 4 | 100 |
| 16 | no cut | 5 | 100 |

Each experimental unit consisted of four lines that were 2.0 m in length with an inter-line gap of 0.30 m. The space between plants was 0.20 m, totaling 40 plants per experimental unit. Within each experimental unit the harvest was carried out in **two times**. In each harvest the two central rows were considered useful, of which other than the plants at the two ends, the central eight plants were harvested.

For this study, seedlings of the cultivar popularly known as 'Baianinha' were used, which were obtained from the study site. The cut tillers had a length of **80-100 mm** and a diameter of 7-10 mm approximately, whereas the uncut ones presented approximately 0.30-0.40 m in length and 7-10 mm in diameter. **The crop management of manual weeding, sprinkler irrigation [3] and cover fertilization with manure of chicken and manure formulated 19-04-19.**

The harvest was carried out in two times: at 73 DAP and 100 DAP, when the plants with and without shoot cut, respectively, reached the harvest point - yellowish leaflets with popping signs. For each harvest period, the following variables were evaluated in the eight plants of the two central rows of each experimental unit: plant length (cm), mass of fresh and dry matter (g), diameter (mm) of each tiller ( $\text{t ha}^{-1}$ ) and number of tillers per plant.

At harvest, each clump was manually removed, washed and the leaves were removed without the commercial standard (scrap). After the evaluations, they were packed in paper bags and placed in a greenhouse with forced air circulation at 65 °C for 72 h.

The values for the commercial fresh matter mass of each experimental unit was used to calculate the productivity ( $\text{t ha}^{-1}$ ). With this value the crop yield was evaluated considering the following indicators: gross income (GI), net income (NI), return rate (RR), and profitability index (PI). The yield ( $\text{t ha}^{-1}$ ) of tillers with commercial pattern was used to obtain GI. For commercialization, a "pack" of 100 g was considered and the nominal wholesale price during the period of the experiment practiced at CEASA-ES de Cariacica was taken into account. The net income was obtained by the difference between the gross income (GI) and the total operating cost (TOC). The TOC was calculated based on the needs of operations and inputs presented in the experiment. The costs related to the inputs, services, and packaging were calculated from the prices practiced in the city of Santa Maria de Jetibá - ES, during the study period. The RR of each treatment was obtained by means of the relationship between GI and TOC and PI by the ratio between NI and GI and expressed as a percentage, according to [8].

The evaluated variables were submitted to normality tests (Lilliefors), additivity (Tukey method), and homoscedasticity (Bartlett), assumptions for the validation of the analysis of variance. As all variables obeyed the assumptions, without data transformation, they were submitted to analysis of variance, considering the main effects of the factors and their interaction in the plots and in the subplots. For the harvesting time factor in the sub-plot and, in the plot, the means were compared by Student t-test. For the factor "number of tillers" and "age" (growth variables) in case of their significant effect, their degrees of freedom were regressed by orthogonal polynomials. An " $\alpha$ " of 0.05 was used for all procedures.

All analyzes were performed using the statistical software SPSS 20.0 [9].

### 3. RESULTS AND DISCUSSION

The variance analysis indicated no significant effect for the interactions ( $P < 0.05$ ), but there was a significant effect with the factors cut and time of harvest. The values observed in the treatments in which the shoot was not cut at the time of planting were higher than those observed in plants that were cut (Table 2).

**Table 2** - Average values of fresh and dry matter ( $\text{t ha}^{-1}$ ) and fresh scrap ( $\text{t ha}^{-1}$ ) mass as a function of the presence or absence of cutting of shoots in tillage

| Variables                                              | Cut of the aerial part |        |
|--------------------------------------------------------|------------------------|--------|
|                                                        | With cut               | No cut |
| Mass of fresh commercial matter ( $\text{t ha}^{-1}$ ) | 27.57b                 | 62.57a |
| Mass of dry commercial matter ( $\text{t ha}^{-1}$ )   | 3.30b                  | 5.69a  |
| Fresh matter mass of scrap ( $\text{t ha}^{-1}$ )      | 8.42b                  | 19.55a |

Averages, followed by the same letters, in the row, are statistically the same, by Student t test (LSD) 5% probability.

The superiority presented by the plants that were not cut may be related to the presence of greater photo synthetically active area. When the plants were not cut, a greater development of the leaf area occurred, providing better conditions to the photosynthetic apparatus. According to [10], the greater accumulation in dry matter obtained as a function of the intercepted and accumulated photosynthetically active radiation is closely linked to the index of leaf area, because, as it rises, the amount of photo synthetically active radiation intercepted is greater, and consequently, the accumulation in phytomass.

When evaluated at 100 DAP, the mass values of the fresh and dry commercial matter, and the mass of fresh scrap were higher than those reached at 73 DAP (Table 3).

**Table 3** - Average values of fresh and dry matter ( $\text{t ha}^{-1}$ ), fresh scrap ( $\text{t ha}^{-1}$ ) mass as a function of the harvesting season

| Variables                                              | Harvest time |         |
|--------------------------------------------------------|--------------|---------|
|                                                        | 73 DAP       | 100 DAP |
| Mass of fresh commercial matter ( $\text{t ha}^{-1}$ ) | 25.29b       | 51.88a  |
| Mass of dry commercial matter ( $\text{t ha}^{-1}$ )   | 2.73b        | 6.26a   |
| Fresh matter mass of scrap ( $\text{t ha}^{-1}$ )      | 8.79b        | 19.17a  |

Averages, followed by the same letters, in the row, are statistically the same, by Student t test (LSD) 5% probability.

This result may be closely related to the growth time in the field. [11] observed that the increase of the cycle was beneficial, evidencing significant gains in the production and commercial dry matter mass of American lettuce. It is worth noting that the mass of fresh and dry commercial matter harvested at 100 DAP provided, respectively, gains of 105% and 129% when compared to the harvest at 73 DAP. Even the mass production of the fresh scrap was higher at 100 DAP, and did not affect the mass of fresh and dry commercial matter.

For plant length, tiller diameter, dry matter mass, and tiller mass, there was interaction between the factors time of harvesting and cutting ( $P < 0.05$ ). Except for the variable mass of fresh matter of tiller, when the time of harvesting was deployed with the cut factor, the plants harvested at 100 DAP presented higher results than those harvested at 73 DAP, regardless of whether the aerial parts of the tiller were cut in the preparation of the seedlings. As for the mass of the fresh matter of the tiller, the plants harvested at 100 DAP presented higher results than the plants harvested at 73 DAP when the aerial part of the seedlings were cut. On the other hand, for the shoots where the aerial part was not cut, there was no significant difference ( $P < 0.05$ ) (Table 4).

**Table 4** - Mean values of plant length (cm), tiller diameter (mm), dry matter mass ( $\text{t ha}^{-1}$ ), and fresh matter mass (g), as a function of presence and absence of cutting of the aerial part of the tillers in the preparation of the seedlings in the different times of harvest

| Cut                                                             | Harvest time |         |
|-----------------------------------------------------------------|--------------|---------|
|                                                                 | 73 DAP       | 100 DAP |
| <b>Plant length (cm)</b>                                        |              |         |
| Cut                                                             | 53.46Bb      | 69.83Ab |
| No cut                                                          | 67.81Ba      | 75.81Aa |
| Mean                                                            | 60.64        | 72.82   |
| <b>Diameter of tiller (mm)</b>                                  |              |         |
| Cut                                                             | 4.62Bb       | 7.75Aa  |
| No cut                                                          | 5.47Ba       | 6.75Ab  |
| Mean                                                            | 5.04         | 7.25    |
| <b>Dry matter mass of scrap (<math>\text{t ha}^{-1}</math>)</b> |              |         |
| Cut                                                             | 0.30Bb       | 1.08Ab  |
| No cut                                                          | 0.76Ba       | 2.39Aa  |
| Mean                                                            | 0.53         | 1.73    |
| <b>Mass of fresh matter of tiller (g)</b>                       |              |         |
| Cut                                                             | 4.66Bb       | 12.09Aa |
| No cut                                                          | 8.14Aa       | 8.75Ab  |
| Mean                                                            | 6.41         | 10.42   |

The highest values observed at harvest at 100 DAP may be related to the increase of the crop cycle, because with the increase of the vegetative cycle the capacity of temporary storage of photosynthates was increased [12]. These same authors also reported a result similar to the present work, when they observed higher values of tiller diameter and fresh and dry matter mass of the chives aerial part at the time of harvesting at the 95 DAP when compared to the 60 DAP harvest.

The mass of fresh tiller matter at 73 DAP was similar to that observed at 100 DAP in plants where the seedlings were not cut. This can be explained by the fact that the plant has invested in the increase in the number of tillers, as can be verified in the linear behavior observed in Figure 1, to the detriment of the biomass formation. In turn, when the evaluation was performed at 100 DAP, the fresh matter mass of the tillers whose plants were cut was higher than those that were not cut. This result may be associated with intraplant competition, where uncut seedlings could develop faster and produced more tillers (Figure 1), so that the plant had to move the absorbed nutrients to a greater number of tillers "when compared to the ones that were cut. [13] evaluated the biomass flow rate and forage accumulation rate in Mombasa grass maintained under different heights and observed that an increase in the till density decreased their size. According to [14], this inverse relationship between number and mass of tillers is explained by the self-thinning law, in which the limiting resource namely light radiation, determines the adjustment in the tiller size / density compensation curve.

For the variable number of tillers per plant (NTP), there was interaction between the factors, time of harvest, number of tillers, and cut ( $P < 0.05$ ). In this way, the harvesting time and cutting factors were divided into the number of tillers by regression analysis (Figure 1).

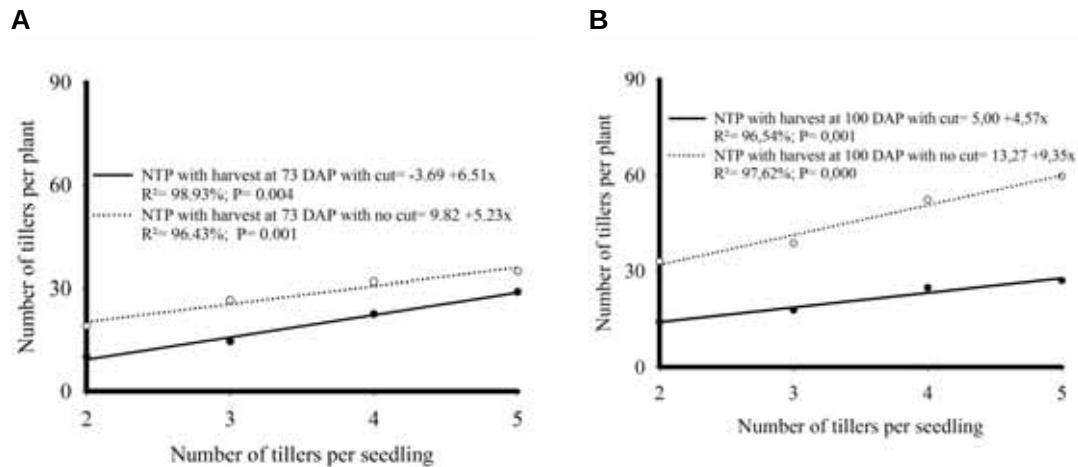


**Figure 1 - Number of tillers per plant in the harvest according to the numbers of tillers in the chive seedlings and the time of harvesting: 73 DAP (A) and 100 DAP (B)**

As the number of tillers at the time of sowing increased, there was an increase in the number of tillers per clump in the harvest. Thus, the highest number of tillers per clump was observed when using five tillers per seedling, the harvest was performed at 100 DAP, and no tillers were cut at the time of planting. These results may be associated with a higher nutrient reserve in the propagation structure of larger (uncut) seedlings, [15], higher capacity of temporary storage of photosynthesis at harvest at 100 DAP [12], and increased sprout capacity of five tillers, proportional to the number of buds for regrowth per seedling [16].

With regard to the number of tillers per seedling, when evaluated, the variables mass of fresh and dry commercial matter, tiller diameter, and mass of fresh and dry tiller showed significant effect ( $P < 0.05$ ). According to the results it is possible to observe that all variables evaluated presented a linear behavior (Figure 2). For the mass of fresh (A) and dry (B) commercial matter, there was a positive response with increase in the number of tillers per molt. On the other hand, the variables tiller diameter (C), mass of fresh tillers (D), and mass of dry tillers (E) showed a negative response, that is, with the increase of tillers by molting there was a reduction in the mean values of these variables.

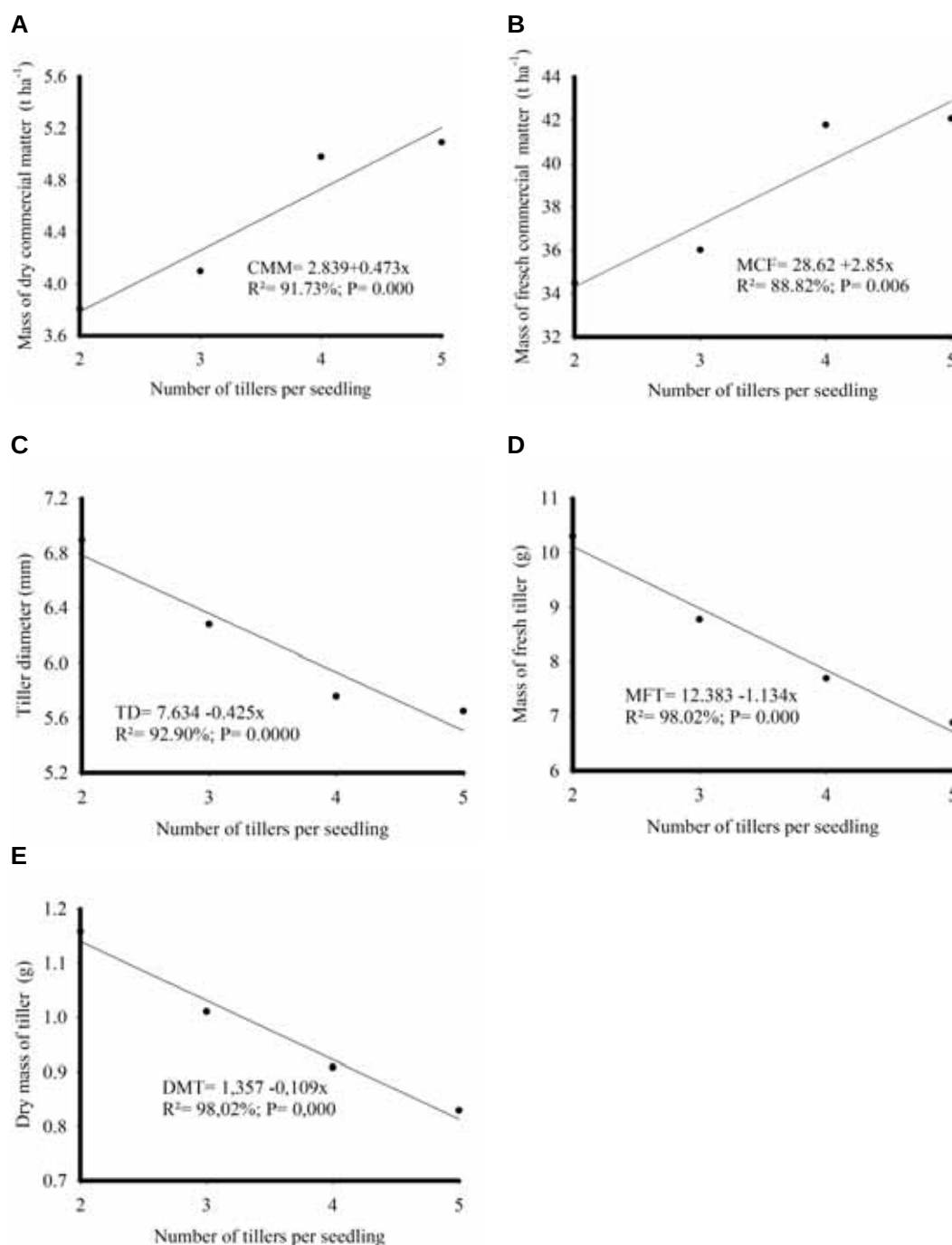


**Figure 2** - Mass of fresh commercial matter (A), mass of dry commercial matter (B), tiller diameter (C), mass of fresh tiller(D), and dry mass of tiller (E) according to the numbers of tillers in the chive seedlings

The positive response in the fresh and dry mass of commercial matter with an increase in the number of tillers per seedlings may be associated with the tillering capacity of the plant. The highest tillering occurs as a result of the increase in the number of buds of the propagation structure [16]. Thus, with the use of five tillers, there is a greater possibility of increasing the leaf area, providing a higher biomass per plant, and consequently, higher values of fresh and dry commercial matter. [17] when evaluating the planting density and harvest method of organic chives verified an increase in the mass of dry matter of clumps and mass of fresh matter of the aerial parts with increase in the density of planting.

On the other hand, the variables tiller diameter, fresh mass, and dry mass of tillers when using a larger number of tillers per seedling, respond negatively. This is due to the competition for water and nutrients, and in plants with the greatest number of tillers, the amount of water and nutrients that each will receive individually will be smaller when compared to a reduced number of tillers per plant. This competition will directly affect the quality and mass of fresh and dry matter of tiller, that is, the plant will produce more tillers with lower biomass. [14] evaluating the size / population density compensation of tillers in Marandu grass pastures (*Brachiaria brizantha* Hochst, ex A. Rich cv Marandu) observed a compensation mechanism of population size / density of tillers by which higher population densities are associated with small tiller numbers, and vice versa.

Regarding the economic indicators, it can be observed that the harvest at 100 DAP presented higher values than the harvest at 73 DAP (Table 5). In the two harvest periods, in the treatments in which the aerial part of the seedlings were not cut, the net income values were higher (Table 5). In relation to the number of tillers in each seedling, in the harvest at 73 DAP when using five tillers per seedling the highest values of net income were observed, regardless of whether the seedlings were cut or not. Meanwhile, in the harvest at 100 DAP, the highest values of profitability index were reached with three and two tillers, respectively, for the treatments with and without cut of the aerial part (Table 5).

**Table 5** - Economic indicators: gross income (GI); net income (NI); return rate (RR), and profitability index (PI) of the chive crop as a function of different numbers of tillers in the seedlings, absence or presence of cutting of the aerial part of the seedling, and the time of harvest

| N° tillers x Cut     | GI<br>(US\$ ha <sup>-1</sup> ) | NI<br>(US\$ ha <sup>-1</sup> ) | RR<br>(US\$/US\$) | PI<br>(%) |
|----------------------|--------------------------------|--------------------------------|-------------------|-----------|
| Harvest at 73 DAP    |                                |                                |                   |           |
| 2 tiller with cut    | 8,172.97                       | 130.74                         | 1,02              | 1.60      |
| 3 tiller with cut    | 11,733.28                      | 1,860.63                       | 1,19              | 15.86     |
| 4 tiller with cut    | 12,867.54                      | 1,494.55                       | 1,13              | 11.61     |
| 5 tiller with cut    | 17,801.57                      | 4,152.80                       | 1,30              | 23.33     |
| 2 tiller with no cut | 29,692.39                      | 19,220.42                      | 2,84              | 64.73     |
| 3 tiller with no cut | 30,240.62                      | 17,955.28                      | 2,46              | 59.37     |
| 4 tiller with no cut | 35,552.73                      | 21,095.51                      | 2,46              | 59.34     |
| 5 tiller with no cut | 37,550.29                      | 21,814.23                      | 2,39              | 58.09     |
| Harvest at 100 DAP   |                                |                                |                   |           |
| 2 tiller with cut    | 28,810.19                      | 18,586.06                      | 2,82              | 64.51     |
| 3 tiller with cut    | 51,095.40                      | 38,098.39                      | 3,93              | 74.56     |
| 4 tiller with cut    | 44,658.31                      | 30,591.54                      | 3,17              | 68.50     |
| 5 tiller with cut    | 41,936.09                      | 26,016.94                      | 2,63              | 62.04     |
| 2 tiller with no cut | 58,521.49                      | 44,911.08                      | 4,30              | 76.74     |
| 3 tiller with no cut | 54,601.99                      | 39,895.64                      | 3,71              | 73.07     |
| 4 tiller with no cut | 58,565.59                      | 40,923.85                      | 3,32              | 69.88     |
| 5 tiller with no cut | 55,402.27                      | 36,772.04                      | 2,97              | 66.37     |

Values of the main inputs and the package of chives used to calculate income: "pack" of 100 g: US\$ 0.05; labor: US\$ 1.85/h; energy: US\$ 0.10 kw/h; stapler: US\$ 61.73; clip: US\$ 1.17 cashier; ribbon: US\$ 1.76; package; manure: US\$ 0.06 kg; fertilizer US\$ 19-04-19: 0.49 kg; seedlings: US\$ 0,0062 un.

Harvest at 100 DAP probably provided superior results due to the longer cultivation period, which led to a higher accumulation of biomass [18]. It is worth mentioning that the increase in the

mass production of fresh and dry matter (Table 3) at 100 DAP did not affect the economic indicators, giving higher values of GI, NI, RR, and PI when compared to the harvest at 73 DAP.

The treatments in which the aerial parts were not cut possibly stood out due to the structure of the seedling. When the shoot is cut, the plant needs to form new leaves to develop, which requires more time [19] and energy [20] for its development. While inplants without the aerial parts cut, the young leaves continue their development not needing the formation of the initial leaves.

In the harvest at 73 DAP, the seedlings with five tillers showed higher values of net income, probably due to the plants being at that time in full development, with intense tillering, and as they possessed more number of tillers in the composition of their molt that were able to grow more rapidly, resulting in higher mass of fresh matter. In contrast, over time (100 DAP) plants with a higher initial tiller number reach the harvest point earlier, favoring a higher mass production of fresh and dry matter of the plants [21]. With the increase in biomass there is a tendency for the mass of fresh refuse matter to also increase (Tables 2 and 3), resulting in an increase in the cost of production due to the labor required for the removal of the non-commercial leaves, affecting the profitability. In turn, seedlings composed of lesser tillers (2 and 3) at 100 DAP showed lower fresh and dry matter mass, requiring less manpower.

In general, it can be emphasized that the results obtained when the aerial part of the seedlings were not cut, and the time of harvest was 100 DAP were superior. Under these conditions, the values found for net income in the present study were higher than those observed by [22], who report that when evaluating the influence of number of heaps, and covering of the soil with chicken bed on the production of chives that were harvested at 64 and 104 DAP, a net income of US\$ 10,299.38 per hectare was obtained from the two harvests.

#### 4. CONCLUSION

The highest mass values of fresh and dry commercial matter of chives are obtained when using five tillers per seedling, by not cutting the aerial part of the tillers at the time of planting, and harvesting at 100 DAP.

When considering the economic indicators of the cultivation of chives, the use of two tillers per seedlings, not cutting the aerial part of the tillers at the time of planting, and harvesting at 100 DAP is recommended.

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