Consortium effect of radish and carrot in the city of Palotina – PR

Efeito de consórcio de rabanete e cenoura na cidade de Palotina – PR

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ABSTRACT
The main objective of this work was to evaluate the effect of the consortium of carrot and radish crops on the efficient use of land. The experiment was developed in the vegetable production area of the Adroaldo Augusto Colombo State Agricultural College in the period from March to June 2019. Three repetitions were performed from the randomized block experimental design. The treatments refer to radish monoculture, carrot monoculture, and consortia of carrot with radish, placing one row of each crop and
alternating them. Crop yields were evaluated by measuring both yield and commercial fresh mass. Commercial diameter and root length were also evaluated. The highest yields were observed when carrots were planted in monoculture and when radish was intercropped with carrots. Although a certain improvement in the carrot yield was observed in terms of monoculture, when the carrot is planted in intercropping, there is a better utilization of the area, as well as of the other resources available. Resources such as the soil itself, nutrients, light, and water. On the other hand, there is the possibility of increasing the diversity of products produced, also promoting a reduction in the economic risks to the producer.

**Keywords:** Daucus carota. Raphanus sativus L. Agroecology.

**RESUMO**
O principal objectivo deste trabalho era avaliar o efeito do consórcio de culturas de cenoura e rabanete na utilização eficiente da terra. A experiência foi desenvolvida na área de produção hortícola da Escola Agrícola Estadual Adroaldo Augusto Colombo, no período de Março a Junho de 2019. Foram realizadas três repetições a partir do desenho experimental de blocos aleatórios. Os tratamentos referem-se à monocultura de rabanete, monocultura de cenoura, e consórcios de cenoura com rabanete, colocando uma fila de cada cultura e alternando- as. Os rendimentos das culturas foram avaliados através da medição tanto do rendimento como da massa fresca comercial. O diâmetro comercial e o comprimento das raízes também foram avaliados. Os maiores rendimentos foram observados quando as cenouras foram plantadas em monocultura e quando o rabanete foi cultivado com cenouras. Embora se tenha observado uma certa melhoria no rendimento da cenoura em termos de monocultura, quando a cenoura é plantada em cultura intercalar, há uma melhor utilização da área, bem como dos outros recursos disponíveis. Recursos tais como o próprio solo, nutrientes, luz e água. Por outro lado, existe a possibilidade de aumentar a diversidade dos produtos produzidos, promovendo também uma redução dos riscos econômicos para o produtor.

**Palavras-chave:** Daucus carota. Raphanus sativus L. Agroecologia.

**1 INTRODUCTION**

The radish (*Raphanus sativus* L.) belongs to the Brassicaceae family and originates from the Mediterranean region RODRIGUES ET AL., (2013). It is usually cultivated on small farms and especially in the green belts of large cities OLIVEIRA et al., (2005). Almost always its cultivation involves a quick return. It generally appears as a complementary source of income in the period 'between crops' that have longer cycles, according to BOARETTO and MURAOKA, (1995); MATOS et al., (2015).

The carrot (*Daucus carota*) has always stood out from the viewpoint of its nutritional diversity. Its edible part is a tuberous root. Its cultivation, in the conventional way, uses mineral fertilizers and synthetic agrochemicals OLIVEIRA, (2001); SEDIYAMA et al., (2002).
BORGES et al. (2011), point out that given the exponential growth of world population, the need to preserve areas not yet deforested as well as various climatic diversities, are only some of the challenges to be overcome by professionals in the agricultural sector regarding the world food supply. In most countries, and especially in developing stages, preference is given to planting combinations, polycultures, or intercropping, usually in single crops. This fact has recently encouraged several studies in this area of study elucidating the benefits and potential of such systems NEGREIROS et al., (2002).

Some alternatives for improving the use of natural resources and the efficiency of the intercropping among vegetables can be carried out: such as the identification of cultivars and the adjustment of population arrangements NEGREIROS et al., (2002); BARROS JÚNIOR et al., (2005).

SALGADO et al. (2006), explained that the intercropping system, or called intercropping, shows itself as the most adequate when the objective is to increase the financial return of crops, having numerous advantages and in several aspects, among them: the environmental and productive factors. This practice is already supported in the daily research in olericulture. Favoring a great increase in the productivity of these crops and their biodiversity. It favors, on the other hand, the ecological balance between the systems states OLIVEIRA et al., (2005).

CAETANO et al. (1999), shows that the same phenomenon does not occur when it comes to monoculture, because it is exclusively intraspecific competition. The chances of success and failure are comparable. However, it is convenient to be tested. It is known that the greater the complementary interference between the species participating in the consortium, the better the specific resources will be used SILVA et al., (2014).

According to the same author mentioned above, with the use of agroecological methodologies that do not harm the environment, farmers, especially those of family base, can value their products in the market, simply by eliminating synthetic fertilizers and pesticides, although the inputs available on site play a key role in how these agrosystems are structured.

Intercropping is one of the main choices currently made by farmers to increase production and profitability among smallholder farmers, especially in the intertropics.

Different spatial arrangements and different sowing times are key factors when it comes to crop management. They can be foreseen with the objective of improving the efficiency of the consortia in vegetables NEGREIROS et al., (2002).
The crops involved in agro-ecological production are determining factors for the success of this system. There is, therefore, a need for complementarity, so that there is better adaptation to the particular conditions of each crop in a way that the intercrop is seen as the most advantageous practice when compared to the monoculture of the vegetable, CECÍLIO FILHO and MAY, (2002).

There are innumerable improvements provided by intercropping systems when compared to single crops, and several benefits can be listed, highlighting the efficient optimization in the use of local natural resources. The results presented by the crops can be improved in three specific situations, such as: through a significant reduction of the phytosanitary problems, since the plants will be well nourished; through the increase of the soil protection, since the producers will be using the same area destined both to the broad-leaved crop and to the ones that produce bulbs or rhizomes. Finally, and very importantly, by the reduction in production costs: using two or more crops in the same planted area HUMPHRIES et al. (2004), ZHANG et al., (2004), HOOKS & JOHNSON (2003), IIJIMA et al., (2004).

BAUMANN et al. (2001) also points out the inherent disadvantages of intercropping, such as the need for more labor and the existence of greater competitiveness among the intercropped species. These characteristics are increased when the species are poorly distributed spatially.

Observing the relevant facts on the subject and with this the objective of the work was to evaluate the intercropping between carrot and radish cultivated in the city of Palotina/PR.

2 MATERIALS AND METHODS

The experiment was managed in the open air, in the period from March 11 to June 16, 2019, in the experimental area of the Colegio Agrícola Estadual Adroaldo Augusto Colombo (CAEAAC), in Palotina, Paraná, Brazil, with geographic data of 24°20'49" S, 53°43'19" O, 366 ma.s.l. According to PRADO (2009), the Oeste Paranaense region predominates soil type 3 (> 35% clay), the region's climate is characterized as mesothermal Cfa, under the influence of a humid temperate climate with summer high temperatures. Soil samples were taken for laboratory analysis according to RAIJ, (2011); see (Table 1). The soil was classified as eutrophic Red Latosol of very clayey texture RIBAS, (2010).
Table 1. Chemical analysis of the soil.

<table>
<thead>
<tr>
<th>Soil samples (m)</th>
<th>pH</th>
<th>S.B.</th>
<th>H+Al</th>
<th>Ca</th>
<th>Mg</th>
<th>K</th>
<th>Al</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 0.20</td>
<td></td>
<td>5.74</td>
<td>71.06</td>
<td>2.71</td>
<td>11.21</td>
<td>3.10</td>
<td>1.12</td>
<td>0.1</td>
</tr>
</tbody>
</table>

1/Soil samples: sum of bases 2/Ca: calcium. 3/Mg: magnesium. 4/K: potassium. 5/Al: aluminum. 6/P: phosphorus.

Initial management of the experimental area was carried out with a tractor clearing using a harrow, followed by a subsoiler, and then the beds were created with a ridger, an agricultural equipment that lifts and decompresses the soil. Ten days before planting, 400 kg/ha of tanned cow manure (from the school itself) was applied and incorporated with hand hoes.

The carrot was planted directly in the beds: both in the intercropping system and in single cropping. A thinning of the excess of plants was carried out in order to maintain the number of plants that would be more likely to result in useful analyses to the project of 1 (one) plant per pit, besides increasing the luminosity and improving the general productive and health characteristics. The evaluations were at 55 and 85 days after germination. The spacing was 0.20 x 0.20m with a total of 20 plants per plot in four rows. According to Figure 1.a., 50% of the plants correspond to the useful area of the plot for the determination of the characteristics: commercial diameter (cm), fresh mass (g) and productivity (t/ha).

In the consortia, each row was occupied alternately, between the crops evaluated, thus, the density in the carrot-radish consortium was the same spacing in the monoculture, maintaining one of the principles of the consortium, according to Figure 2. Irrigation occurred when necessary, using a simple sprinkler.

The commercial fresh mass of each crop was determined by dividing the sum of the mass of the plants by the number of plants harvested in each plot. This data is then used to determine the yield calculation, in accordance with the number of plants per hectare.

A metal caliper was used to calculate the commercial diameter and a 30 cm metal scale was used to calculate the root length.

Based on the productivity parameters (commercial production), the efficient land use was calculated using Equation 1:

\[
ET = \left(\frac{C_{\text{carrot}}}{M_{\text{carrot}}}\right) + \left(\frac{C_{\text{radish}}}{M_{\text{radish}}}\right) \quad \text{Eq.1}
\]

Where: \( C = \) is the productivity of the intercrop, referring to the carrot and radish species; \( M = \) productivity of the single crop.
The values obtained were submitted to the analysis of variance to Tukey test at 5% probability.

3 RESULTS

The results of productivity and efficient land use in the radish-carrot intercrop experiment are outlined in Table 2.

Table 2. Agronomic performance, productivity and Efficient Land Use Index (ETU) under agroecological planting for carrot and radish crops in single and intercropping - Palotina, CAEAAC, 2018.

<table>
<thead>
<tr>
<th>Crop system</th>
<th>MFc (g)</th>
<th>DC (cm)</th>
<th>CR (cm)</th>
<th>Prod. (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carrot (consort with radish)</td>
<td>123.82a</td>
<td>13.70a</td>
<td>15.47b</td>
<td>66.51a</td>
</tr>
<tr>
<td>Carrot (monocrop)</td>
<td>122.45b</td>
<td>12.31b</td>
<td>16.11a</td>
<td>68.68b</td>
</tr>
<tr>
<td>UET – Carrot-Radish</td>
<td>1.01</td>
<td>1.11</td>
<td>0.96</td>
<td>0.96</td>
</tr>
<tr>
<td>Radish (carrot consort)</td>
<td>123.64b</td>
<td>15.52b</td>
<td>-</td>
<td>22.46b</td>
</tr>
<tr>
<td>Radish (Radish monocrop)</td>
<td>152.98a</td>
<td>12.10a</td>
<td>-</td>
<td>25.72a</td>
</tr>
<tr>
<td>UET Radish – Carrot</td>
<td>0.80</td>
<td>1.28</td>
<td>0.87</td>
<td></td>
</tr>
</tbody>
</table>

Metals followed by the same letter do not differ by the Tukey test - 5% probability.

After the evaluations, more expressive results were found when carrots were intercropped with radish. As for the radish cultivated alone, a greater response was obtained in fresh mass (g) with values between 123.82 and 152.98, both in grams.

In Figure 1, are the graphs of the individual effects of yield and MFc in the monoculture planting of carrot and the consortium between carrot and radish. The same behavior is verified for both variables.

Figure 1. Effects plots on carrot in monoculture and intercropped with radish in the field CAEAAC, 2019 - Palotina, 2018.
Figure 1.A shows that when changing from single carrot cultivation to intercropping, there was a significant increase in productivity. The same occurs when the MFc is analyzed as shown in Figure 1.B.

Figure 2 shows the graph of the individual effects of yield, MFc and root diameter in the radish planting in single cultivation and in intercropping with carrot. The same behavior is observed for both variables.

Figure 2. plots of effects of radish in single and intercropping with carrot in the field, CAEAAC, 2019 - Palotina.

Figure 2.A shows the same results graphically, making it evident that by changing the planting of the radish, in single cultivation, to intercropping, the result would appear in the form of a significant improvement in the final productivity of the system. The same fact occurs when analyzing the MFc, where the root diameter shows an inverse value (Figures 2.B and 2.C).

4 DISCUSSION

According to the Table, The productivity of the carrot, in t/ha, was 68.68 in monoculture and 66.51 in the intercrop with the radish, being superior to the values cited by RIBEIRO et al. (1993).

With regard to the average productivity of radish, in single cultivation, an average of 25.72 t/ha was obtained, exposing the hypothesis to be similar to the conventional way of conducting the crop FILGUEIRA, (2008). In turn, the average productivity of radish intercropped with carrot was 22.46 t/ha, compatible with the estimates for the form of intercropping, either with lettuce or carrot FILGUEIRA, (2008).

These results were reaffirmed with those obtained by Caetano et al. 1999, in which they worked in intercropping between carrot and lettuce. BEZERRA NETO et al. (2003),
evaluating 4 (four) different cultivars of lettuce, intercropped with carrot, obtained UET responses of 16 and 11%, respectively. However, the results in this study are below these percentages, but even so when the result is greater than 1.0 there is a high efficiency in the results (Table 2).

CAETANO et al. (1999) evaluated a consortium of lettuce with carrots, and observed different responses to that presented in this research, because the results presented by the authors were 70% greater UET in the intercropping system. In the same line of reasoning, OLIVEIRA et al. (2005) managed to optimize the UET to 59% when they had intercropped radish with cabbage, using post Crotalaria juncea management.

According to the Figure 1, even working with crops of species of greater similarity, such as carrot and radish, there was no competition regarding: the population and the attack related to pests, because knowing that the increase in population density can interfere with the nutrient absorption system and other important factors for the production of photosynthesis, as cited MACHADO et al., (2005).

We sought to analyze the results according to the theories of BARROS JÚNIOR et al. (2005), when there is an increase in plant population density per unit area, what can and does happen is a competition among the producing plants themselves. This competition tends to reduce the available resources and affect the development and especially the final productivity of the crops.

A small classification of the carrots harvested in both systems showed small root types. Based on the measurements made in these results, it can be concluded that RIBEIRO et al. (1993), reaffirm that what could be causing low productivity of carrots in relation to the increase of the population density is related to the increase of the population density.

For the commercial quality of the carrot, the single cropping system is recommended, since the crop suffers direct influence of the intercrops. The responses to intercropping and monocropping, both for carrot and radish, were of reference values regarding productivity and Efficient Land Use.
REFERENCES


