Growth and Yield of Three Carrot Plant Cultivar on Different Planting Distance

Ahmad Taofik1, Budy Frasetya T.Q1, Rosihon Anwar2, Setia Gumilar3, Rusyad Mutaqin Kurnia1

1.Agrotechnology Department, Faculty of Science and Technology, UIN Sunan Gunung Djati Bandung Street A. H. Nasution 105 Bandung 40614, West Java, Indonesia
2. Islamic Education Department, Faculty of Ushuluddin, UIN Sunan Gunung Djati Bandung Street A. H. Nasution 105 Bandung 40614, West Java, Indonesia
3. Islamic Education Department, Faculty of Adab and Humainora, UIN Sunan Gunung Djati Bandung Street A. H. Nasution 105 Bandung 40614, West Java, Indonesia

Abstract. The selling price of high-quality carrot has a higher selling price compared to the low-quality carrot. Setting plant distance and planting superior cultivars can improve yield quality. This study aims to study the interaction of carrot plant cultivars and plant spacing on the growth and yield of carrot plants. The study was conducted in June 2016-September 2016 in Pasirhalang-Cisarua-West Bandung (1,100 m asl). The experimental research method used in this study uses a split-plot design. The main plot is carrot plant cultivars (v1=Kuroda EW Select, v2=New Kuroda, v3=Red Judy) and subplots are spacing (j1=7.5 cm x 7.5 cm, j2=10 cm x 10 cm, j3=12.5 cm x 12.5 cm, j4=15 cm x 15 cm) each experiment unit is repeated three times each. Growth and yield parameters observed were plant height, crown width, plant dry weight, tuber length, and fresh weight of carrot. Data from observations were then analyzed using variance at 5% significance level, and Duncan's mean difference test at 5% significance level. The results showed that the spacing of 15 cm x 15 cm and cultivar Kuroda EW Select produced the highest growth and yield of carrot plants. The selection of carrot plant cultivars and spacing can increase crop yields.

Keywords: carrot, growth, yield, planting distance

1. Introduction
Generally, carrot cultivation methods in Indonesia have not applied spacing since the beginning of planting (Fai, 2018) so that the yield is lower than the genetic potential of each cultivar carrot planted. Carrots in Indonesia are generally consumed in processed form, either cooked directly or as a pickling ingredient. The process of cutting carrots causes the shape, size, and weight of carrots to be rarely considered. The conditions for low and high-quality crops still have their market share, so this is why the spacing has not been implemented at the beginning of planting. In general, farmers adjust the spacing
using the thinning method, but this method has a shortage of irregular spacing. Tightly spacing causes competition for nutrients and other growth factors, resulting in low yields with uneven quality (Fai, 2018; Resende et al, 2016).

The modern retail market's development demands that the carrots on display are relatively uniform in size, shape, and weight. The sorting process makes it possible to meet these needs, but the carrot yields that do not meet the grade will be high or the percentage of rejected carrot quality will be high. According to Brown & Gracie (2000) uniformity of carrot at harvest, the size and the shape of carrot is critical based on cultivation management. The carrot yield that fulfils modern market needs, the input of cultivation technology is needed to achieve the percentage of product quality expected (Adnan & Laksono, 2013). This study aims to study the interaction between cultivar types and spacing on carrots' growth and yield. The research results are needed as a qualitative basis in production planning.

2. Methods
This research was conducted in Desa Pasirhalang-Cisarua, West Bandung Regency (+1,100 m above sea level). The tools and materials used in this study were hoes, buckets, measuring tapes, scales, carrot seeds, manure, NPK fertilizer, zeolite, and dolomite. The research method used was experimental research using a plot design divided into two factors. The first factor is the variety (v1 = Kuroda EW Select, v2 = New Kuroda, v3 = Red Juddy) and the second factor is the spacing (j1 = 7.5 cm x 7.5 cm, 10 cm x 10 cm, 12.5 cm x 12.5 cm, 15 cm x 15 cm). The combination level of each factor was repeated three times to obtain 36 experimental units.

The research procedure begins with tillage using a plow with a depth of 40-50 cm. Then proceed with the manufacture of beds measuring 1 m x 2 m and chicken manure application at a dose of 15 t ha\(^{-1}\). The planting process is carried out by making planting holes in the beds according to the spacing treatment level. Each planting hole is filled with two carrot seeds. Fertilization is given after the plants are 30 days old. The fertilizer given is a fertilizer that has been diluted, consisting of 4 kg of NPK, 2 kilograms of zeolite, and 1 kilograms of dolomite, then water is added to the volume of 100 liters. The dosage of fertilizer application is 7 liters per bed. The observed growth and yield parameters were planted height 90 days after planting (DAP), plant canopy 90 DAP, plant dry weight, tuber length, and tuber weight or carrot yield. The data from the observations were then analyzed using analysis of variance at the 5% significance level and Duncan's multiple range test at the 5% significance level

3. Results and Discussion
The results of the analysis of variance (Table 1) of carrot cultivar types at different spacing showed the effect of the interaction on the plant height parameters of 90 DAP and fresh carrot weight. Cultivar type and spacing independently affect plant canopy 90 DAP, plant dry weight, and tuber length.

| Parameters               | F-value       |
|--------------------------|---------------|
|                          | V   | J    | VxJ |
| Plant Height 90 DAP      | 245,72* | 11,86* | 5,46* |
| Plant canopy 90 DAP      | 878,86* | 28,23* | 1,56ns |
| Plant dry weight         | 149,15* | 41,67* | 2,49ns |
| Tuber length             | 38,02*  | 25,15* | 0,64ns |
| Tuber Weight             | 56,05*  | 87,74* | 3,49* |
3.1 Plant Height
According to the results of the analysis of variance (Table 1), cultivar type, and spacing influence each other on plant height. Types of cultivars have their individual genetic and phenotypic traits, but if environmental factors do not support growth, their genetic markers cannot be seen. Spacing affects the competition for nutrient uptake, water, and sunlight between plants (D’Hooghe et al., 2018). Plants visually deprived of sunlight show symptoms of excessive increase in plant height, have weaker stems or fall easily (Frasetya, Rahmatullah, & Subandi, 2020).

In Table 2 it shows that carrot cultivars planted at a denser distance were higher than those grown at more tenuous spaces. The spacing of 12.5 cm x 12.5 cm in all cultivars tested showed better plant height growth.

### Table 2. Plant Height

| Cultivar | Planting Distance (cm) |
|----------|------------------------|
|          | j1 | j2          | j3 | j4          |
| v1       | 54,75 b | 55,35 b | 47,65 a | 49,81 a |
|          | B  | B          | B  | B          |
| v2       | 58,22 b | 56,21 b | 49,7 a  | 47,98 a |
|          | B  | B          | B  | B          |
| v3       | 35,41 b | 34,53 a | 36,28 a | 36,10 a |
|          | A  | A          | A  | A          |

Note: The numbers followed by the same letters (lowercase letters horizontally and capital letters vertically) indicate no significant difference according to Duncan Multiple Range Test at 5% level.

3.2 Plant canopy, plant dry weight, and Tuber Length
The results of the analysis of variance (Table 1) show that the parameters of the plant canopy, plant dry weight, and tuber length are independently influenced by cultivar type and plant spacing. Cultivar Kuroda EW Select and New Kuroda have the same characteristics but are significantly different from the Red Juddy cultivar's characteristics. The right cultivar type and planted in the right location will produce plant growth following its genetic potential (Saraswati et al., 2013). The spacing has a significant effect on the canopy width parameters, plant dry weight, and tuber length (Table 3).

Carrot plants showed better growth at a spacing of 12.5 cm x 12.5 cm than those with closer spacing or with high density. In plants that grow with less distance or low density, the competition for nutrients, sunlight, and water can be reduced to fulfill their basic needs (Kharsan, Nag, Dk, & Lp, 2019; Safayet, Arefin, & Hasan, 2017). At a 15 cm x 15 cm spacing, the plant dry weight parameter showed the highest yield compared to other spacing. These results indicate that biomass formation is sensitive to the availability of nutrients, water, and sunlight. In the root length or tuber length component, the spacing of 12.5 cm x 12.5 cm or 15 cm x 15 cm results in tuber length.

3.3 Tuber Weight
The variance analysis (Table 1) showed that carrots' tuber weight was influenced by the type of cultivar and the spacing. The highest tuber weight was obtained in the Kuroda EW Select variety at a spacing of 15 cm x 15 cm, and the lowest tuber weight was in the Red Juddy variety with a spacing of 7.5 cm x 7.5 cm.
cm. Observation of tuber weight as a harvest parameter confirms previous studies' results that cultivar species will show their genetic potential if environmental factors are sufficient (D’Hooghe et al., 2018).

Each cultivar type requires unique environmental conditions; for example, in the New Kuroda cultivar, the tuber weight at a spacing of 12.5 cm x 12.5 cm, and a 15 cm x 15 cm spacing resulted in an insignificant difference in tuber weight. Plants that grow early require more nutrients, water, and sunlight than cultivars with slow growth (Kharsan et al., 2019).

Table 3. Plant Canopy, Plant Dry Weight, Tuber Lenght

| Treatments | Plant canopy 90 DAP | Plant dry weight | Tuber length |
|------------|-------------------|-----------------|-------------|
| Cultivar   |                   |                 |             |
| v1         | 37,13 b           | 15,28 c         | 15,84 b     |
| v2         | 36,24 b           | 13,17 b         | 15,53 b     |
| v3         | 25,18 a           | 6,25 a          | 13,27 a     |
| Planting distance |       |                 |             |
| j1         | 29,95 a           | 7,85 a          | 13,17 a     |
| j2         | 32,51 b           | 10,28 b         | 14,66 b     |
| j3         | 34,18 c           | 12,34 c         | 15,78 c     |
| j4         | 34,76 c           | 15,79 d         | 15,91 c     |

Note: The numbers followed by the same letters vertically indicate no significant difference according to Duncan Multiple Range Test at 5% level

Table 4 Tuber Weight

| Cultivar | Planting Distance (cm) | j1 | j2 | j3 | j4 |
|----------|------------------------|----|----|----|----|
| v1       | 64,99 a                | B  | B  | B  | B  |
|          | 90,43 b                | B  | A  | A  | A  |
| v2       | 64,55 a                | B  | B  | B  | B  |
|          | 78,28 a                | B  | A  | A  | A  |
| v3       | 29,76 a                | A  | A  | A  | A  |
|          | 41,58 ab               | A  | A  | A  | A  |

Note: The numbers followed by the same letters (lowercase letters horizontally and capital letters vertically) indicate no significant difference according to Duncan Multiple Range Test at 5% level

4. Conclusion

The results showed that the spacing of 15 cm x 15 cm and cultivar Kuroda EW Select produced the highest growth and yield of carrot plants. The selection of carrot plant cultivars and spacing can increase crop yields.

5. Acknowledgments

We say thank you to Lembaga Penelitian dan Pengabdian kepada Masyarakat (LPPM) UIN Sunan Gunung Djati Bandung for supporting publication.
References

[1] Adnan, & Laksono, P. (2013). Effect of spacing on carrot harvest quality. In Akselerasi Pemanfaatan Teknologi Pertanian Spesifik Lokasi Mendukung Ketahan Pangan dan Kesejahteraan Petani Nelayan. Jakarta: Balai Besar Pengkajian dan Pengembangan Teknologi Pertanian.

[2] Brown, P., & Gracie, A. (2000). Factors Influencing Carrot Size and Shape. Sydney: Horticultural Australia Ltd.

[3] D’Hooghe, P., Diaz, D., Brunel-Muguet, S., Davy, M., Vial, F., Dubois, J., & Kauffmann, F. (2018). Spatial variation of root yield within cultivated carrot fields is strongly impacted by plant spacing. Scientia Horticulturae, 241(January), 29–40. https://doi.org/10.1016/j.scienta.2018.06.072

[4] Fai, M. D. (2018). Pengaruh Jarak Tanam dan Takaran Pupuk Kandang Sapi terhadap Pertumbuhan dan Hasil Tanaman Wortel (Daucus carota L.). Savana Cendana, 3(03), 47–49. https://doi.org/10.32938/sc.v3i03.314

[5] Frasetya, B., Rahmatullah, P., & Subandi, M. (2020). Application of Rice Husk Silicate Extract to Increment Growth of Indoor Hydroponic Lettuce. IOP Conference Series: Earth and Environmental Science, 542, 012025. https://doi.org/10.1088/1755-1315/542/1/012025

[6] Kharsan, M., Nag, K., Dk, S., & Lp, B. (2019). International Conference on “Food Security through Agriculture & Allied Sciences” To assess the effect of spacing on growth and yield of carrot (Daucus carota L.) Cv. Pusa Kesar. Journal of Pharmacognosy and Phytochemistry, SP5, 77–80.

[7] Resende, G. M. D. E., Yuri, J. E., & Costa, N. D. (2016). Planting Times and Spacing of Carrot Crops in the Sào. Rev. Caatinga, 29(3), 587–593.

[8] Safayet, M., Arefin, M. F., & Hasan, M. M. U. (2017). Present practice and future prospect of rooftop farming in Dhaka city: A step towards urban sustainability. Journal of Urban Management, 6(2), 56–65. https://doi.org/10.1016/j.jum.2017.12.001

[9] Saraswati, P., Soplanit, A., Syahputra, A. T., Kossay, L., Muid, N., Ginting, E., & Lyons, G. (2013). Yield trial and sensory evaluation of sweetpotato cultivars in Highland Papua and West Papua Indonesia. Journal of Tropical Agriculture, 51(1–2), 74–83.