The response of Stecklings Age and Plant Spacing on Carrot Seed Quality and Production

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ABSTRACT

The quality of seed needs to be considered in carrot seed production to maintain its productivity. The research aims to find out the response of stecklings age and plant spacing on carrot seed quality and production. This research was held on July 2018 – April 2019 in Berastagi field trial (1340 m MSL). The experiment used Randomized Complete Block Design (RCBD) with two factors, i.e., stecklings age (2 and 3 months) and plant spacing (25, 50, 75, and 100 cm), replicated four times (32 experiment units), 10 plants from each experiment units were taken as samples. The result showed that stecklings age and plant spacing were affected to plant vegetative and generative stages. The combination of 2-month stecklings and 50 cm plant spacing increased the number of secondary umbel, if compared to cultivation, which was generally used by the farmer (3-month stecklings and 25 cm plant spacing). The best quality of carrot seed was obtained from the combination of 3-month stecklings and 50 cm plant spacing.

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1. INTRODUCTION

Carrot cultivars have different carotenoid content and composition, different steckling shapes and colors, i.e.: white, yellow, orange, or red (covered by purple anthocyanin) (Baranski, et al., 2012). Gundaling is one of the carrot varieties originated from Berastagi and more preferred by the consumer because of its sweetness, crispness, and dominant orange color. Manik, et al. (2017) mentioned three carrot varieties in Berastagi based on its morphological character, i.e., yellow carrot, a large core of orange carrot, the small core of orange carrot. Carrot cultivation is directly planting with seeds. Seed production in farmers rarely noticed the seed quality; meanwhile, the high quality of seed is one of the key success in the agriculture business.

Stecklings with bigger neck diameter have greater food reserves and are usually used as propagation resources (Hadirocmat, 2006). Malek, et al. (2012) explained that umbel pruning and position determined the quality of carrot seed and affected the seed characteristics (size and weight of seed). Anjum & Amjad (2002) stated that the closer spacing between plants, the seed production per plant is lower. Dan, et al. (2017) reported that the plant spacing affected the number of productive seeds and pithy seeds on rice.

Carrot seeds can be produced in two different methods,

i.e., seed-to-seed and root-to-seed. The seed production method which used in Berastagi is root-to-seed. This method makes it possible to choose the healthy roots and appropriate the desired criteria for replanting. Carrot seed production in farmers is hindered by the availability of quality seeds in large quantities. The appropriate carrot cultivation, especially using healthy propagation resource and plant spacing, is expected to increase seed production. The research aims to find out the response of stecklings age and plant spacing on carrot seed quality and production.

2. MATERIALS AND METHODS

This research was held in July 2018 - April 2019 in Berastagi field trial (1340 m MSL). Stecklings from Gundaling variety with different harvest periods, i.e., 3-month stecklings with average neck diameter to 3.5 cm and root length to 16 cm; 2-month stecklings with average neck diameter to 2.5 cm and root length to 13 cm. Stecklings were collected from Berastagi field trial.

2.1 Experimental Research

The experiment used a randomized complete block design with two factors, i.e., stecklings age (2 and 3 months) and plant spacing inside the rows (25, 50, 75, and 100 cm); meanwhile, the plant spacing between rows

was 100 cm. There were eight combinations of experiment units and replicated four times (32 experiment units). Each experiment unit consists of 10 plants that were taken as samples.

2.2 Implementation

Criteria of stecklings used in root-to-seed method were unbranched root, free from pests, not cut off (intact root), and the availability of buds. Stecklings were cut $\frac{1}{4}$ from the tip. Stecklings cutting triggered the emergence of new fibrous root. The leaves were cut, leaving 10 cm of the petiole (Figure 1). Stecklings were planted up to the neck of it according to the plant spacing treatment. Stecklings maintenance was in the form of embellishment, weeding, stick treatment, and pruning tertiary branches.

Figure 1. Selected stecklings, (A) intact stecklings; (B) quarter cut stecklings

Brown umbels showed that seed had already been harvested, then mature umbel was dried and continued with threshing. Seed physiology quality testing used the top of the paper method inside a plastic box and germinated at room temperature. Each treatment consists of 4 replicates, with 100 seeds in one sample.

This experiment used plant height for the vegetative parameter. Plant heights were measured after flowering, started from the ground level until the highest umbel. Generative parameters were total secondary umbels, umbel diameters, umbel weights, and seed weights. These generative parameters were observed after harvesting, which was taken from primer and secondary branches.

Seed quality parameters: 1) Weight of 1000 seeds were determined by counting the average of 100 pure seeds weight for 8 replicates; 2) Seed germination percentage was evaluated from total normal sprouts on an observation I (6th day) and II (12th day), then divided with a total number of planted seeds and multiplied by 100%; 3) Maximum growth potential were calculated by the percentage of normal and abnormal sprouts which appeared until the 12th day of observation. The maximum growth potential formula was total germinated seeds divided with total planted seeds, then multiplied with 100%.

2.3 Statistical Data Analysis

Data of Analysis of Variance (ANOVA) and means comparison was computed by R software. DMRT test was used to analyze significant differences in different levels of treatment with a probability 5%.

3. RESULTS AND DISCUSSIONS

The analysis result showed an interaction between stecklings age and plant spacing to the number of total secondary umbels and umbel weights. The flowering plant heights were affected by stecklings age but negative response for plant spacing (Table 1).

Flowering plant height from 3 months stecklings is higher than 2-month stecklings, respectively 47.6 and 32.3 cm. The higher plant from 3-month stecklings allegedly because of the bigger root diameter triggered the emergence of fibrous roots useful for water and nutrient absorption for plant growth.

Plant spacing did not affect plant height. The average plant height at a different level of plant spacing was 39.9 cm. Similar results were obtained from Gray (1981) research; there were no significantly different plant density effects to plant height.

Table 1. Effect of Steckling Age and Plant Spacing on Carrot Plant Height

Treatments	Plant Height (cm)
Stecklings Age	
3 months	47.6 a
2 months	32.3 b
Average	-
Plant Spacing	
25 cm	42.0
50 cm	41.1
75 cm	37.8
100 cm	38.7
Average	39.9
Stecklings Age x Plant Spacing	
KK (%)	tn
	17.4

Note: The number followed by the same letter in same column shows no significant effect based on DMRT test at $\alpha = 5\%$, tn: not significant

Stecklings age significantly affected total secondary umbels, umbel weights, and seed production but not significantly on umbel diameter. Meanwhile, plant spacing influenced the number of secondary umbels and umbel weights but not significant on umbel diameter and seed production (Table 2). There was an interaction between stecklings age and plant spacing to the number of secondary umbels and seed weights (Table 3).

Table 2. Effect of Stecklings Age and Plant Spacing to Number of Secondary Umbels, Umbel Diameters, Umbel Weights, and Carrot Seed Production

Treatment	Number of Secondary Umbels	Umbel Diameters (cm)	Umbel Weights (g)	Seed Production (g)
Stecklings Age				
3 months	6.3 b	10.4	4.5 b	139.5 a
2 months	8.8 a	11.0	6.2 a	70.3 b
Average	-	10.7	-	-
Plant Spacing				
25 cm	7.5 a	10.3	4.4 b	93.6
50 cm	8.4 a	10.5	4.6 b	116.1
75 cm	7.9 a	11.0	4.7 b	113.7
100 cm	6.4 b	11.0	7.8 a	96.2
Average	-	10.7	-	104.9
Stecklings Age x Plant Spacing	significant	insignificant	significant	insignificant
KK (%)	10.8	9.7	16.5	5.23

Note : The number followed by the same letter in the same column shows no significant effect based on DMRT test at $\alpha = 5\%$, tn: not significant

Two months stecklings produced the highest number of secondary umbels and umbel weights, however, seed production was lower than 3-month stecklings. Umbel diameter was not affected by stecklings age, where the umbel diameter average was 10.7 cm (Table 2).

Seed production was correlated with stecklings age; this showed the importance of propagation source compatibility with the physical aspect and stecklings age. Three-month stecklings had a bigger size because of the maximum root enlargement and carotenoid accumulation. Dev (2010) and Kumar, et al. (2017) stated that the highest seed production was obtained from bigger stecklings (150–175 g). Gray (1981) explained that stecklings selection was the important phase in seed production, especially for the root-to-seed method.

Seedless umbel is one of the carrot flowering problems. Individual carrot flowers are normally protandrous, where male flowers ripen first before female flowers. Male flowers in carrots tend to have a higher percentage of appearance. Braak & Kho (1958) stated that pollinating insects for pollination were contradictive with seed production decreasing. Dyki *et al.* (2010) added that

morphological characters that can reduce the number of seeds were green petals, small nectar, ovule and embryo degenerations, anthers and pollens degenerations, and the absence of ovaries.

The highest number of umbels were collected from 50 cm plant spacing treatment (8.4 umbels), but not differ with 75 cm (7.9 umbels) and 25 cm (7.5 umbels) plant spacing. Meanwhile, the highest umbel weight harvested from 100 cm plant spacing treatment (7.8 g), significantly different with 25, 50, and 75 cm plant spacing. Umbels weight on 25, 50, and 75 cm plant spacing were not significantly different, with 4.4, 4.6, and 4.7 g, respectively.

Umbel diameter and seed production were not affected by plant spacing. The average umbel diameter and seed productions were 10.7 cm and 104.9 g, respectively. The number of secondary umbels increased with 50 cm plant spacing, and the combination of 100 cm plant spacing and 2-month stecklings treatments increased the weight of umbels. This showed that the number of secondary umbel and umbel weight was influenced by plant spacing and stecklings age (Table 3).

Table 3. Stecklings Age and Plant Spacing Interaction to Number of Secondary Umbels and Umbel Weight

Plant Spacing	Stecklings Age	
	3 months	2 months
.....The number of Secondary Umbel.....		
25 cm	6.25 c	8.92 b
50 cm	6.15 c	10.70 a
75 cm	6.60 c	9.28 b
100 cm	6.45 c	6.45 c
.....Weight of Umbel.....		
25 cm	4.12 b	4.71 b
50 cm	4.75 b	4.47 b
75 cm	4.77 b	4.64 b
100 cm	4.67 b	11.9 a

Note : The number followed by the same letter in same column shows no significant effect based on DMRT test at $\alpha = 5\%$

Two months stecklings appropriate for umbel production because of root enlargement was maximum. The highest number of umbels was obtained from 50 cm plant spacing, showed that that plant spacing was already enough to produce a maximal number of umbels, while umbel weight connected with larger plant spacing. Gray, et al. (1983) explained that increasing plant spacing could reduce the number of secondary umbel per plant. Kumar, et al. (2017) added that plant growth and seed production

were influenced by larger plant spacing because of the wider growing area and less competition in nutrition, sun, and air.

Stecklings age influenced seed germination but not to the weight of 1000 seeds and maximum growth potential. Plant spacing affected the weight of 1000 seeds and seed germination but not influenced seed maximum growth potential (Table 4).

Table 4. Influenced of Stecklings Age and Plant Spacing to Carrot Seed Quality

Treatment	Weight of 1000 Seeds (g)	Seed Germination (%)	Maximum Growth Potential (%)
Stecklings Age			
3 months	0.11	56.1 a	71.1
2 months	0.12	45.7 b	63.6
Average	0.11	-	67.3
Plant Spacing			
25 cm	0.09 c	45.7 b	64.0
50 cm	0.13 a	48.7 b	63.2
75 cm	0.11 b	51.2 ab	68.0
100 cm	0.11 b	58.0 a	74.2
Average	-	-	67.35
Stecklings Age x Plant Spacing	insignificant	insignificant	insignificant
KK (%)	15.7	14.9	15.2

Note : The number followed by the same letter in the same column shows no significant effect based on DMRT test at $\alpha = 5\%$, tn: not significant

Combination treatment of 100 cm plant spacing and 3-month stecklings resulted in the highest seed germination (56.1%). The percentage of carrot seed germination in this research was categorized as a low percentage. The minimum standard of quality seed is 75% as mentioned in Minister of Agriculture Decree no: 71/Kpts/SR.130/D/9/2017.

Seed germination percentage influenced by some factors, i.e., condition before planting (seed condition and storage environment) (Purbojati & Suwarno, 2006); pollination technique and fertilization (Dyki, et al., 2010); environmental stress often decreases the rate of seed germination (Delian & Lagunovschi-Luchian, 2015); high plant density or tight plant spacing (Merfield, et al., 2001).

Plant spacing treatment significantly influenced the weight of 1000 seeds, where the highest weight on 50 cm and the lowest weight on 25 cm plant spacing. This result was compatible with (Merfield, et al., 2001) research; the more number of plants, the weight of 1000 seeds is lower. Stecklings age has not influenced the weight of 1000 seeds, with an average of 0.11 g. The maximum growth potential of seed was not influenced by the stecklings age, too, with an average of 67.3%.

4. CONCLUSION

Combination of 2-month-old stecklings and 50 cm plant spacing was the best treatment to increase plant generative phase, especially on the number of secondary umbels. The best quality of seed was obtained from combination planting of 3-month stecklings and 50 cm plant spacing.

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