Effect of biofertilizer on growth and yield of carrot *(Daucus Carota* L.) plants in different latitudes of Lombok Island

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Abstract. Carrot is an important sub-tropical vegetable, and in the tropics it is commonly cultivated in high elevated mountainous areas to provide suitable environment (particularly temperature) for the optimum growth and productivity. Availability of suitable cultivation areas in Indonesia is limited while demand for the crop is increased. This research evaluated growth and yield of carrot in warmer temperature of lower land elevations, and examined capability of biofertilizer to increase growth responses and yield of the crop under sub-optimal temperature conditions. The first and second experiments were conducted in medium latitudes of 650 m above sea level (asl) and 550 m asl, while the third experiment was conducted in low land of 170 m asl. The experiments compared growth and yield of carrot plants with biofertilizer and without biofertilizer applications. The growth and yield of carrot were enhancing by biofertilizer application when planted in ca. 650 and 550 m asl. The biofertilizer-treated plants were taller, had a higher number of leaves, higher yield, carrot diameter and sweater than non-treated plants. In low land, however, biofertilizer bio-EXTRIM had no effect on plant growth and yield but the carrots in biofertilizer treated plants were sweeter than non-treated plants.

1. Introduction

Carrot (*Daucus carota* L.) is an important root vegetable in Indonesia due to the demand and high nutrition value. The carrot root is an important source of carotenoid, vitamins, minerals and dietary fiber. Every 100 g of fresh carrot root contains 173 kJ (41 Kcal) energy, 9.6 g carbohydrate, 4.7 g sugar, 2.8 g dietary fiber, 0.24 g lipids, 0.93 g protein, 33 mg (7%) calcium, 0.3 mg (2%) iron. 12 mg (3%) magnesium, 0.143 mg (7%) manganese, 35 mg (5%) phosphor, 320 mg (7%) potassium, 0.,24 mg (3%) zinc, 69 mg (5%) sodium, 0.066 mg (6%) thiamine, 0.058 mg (5%)riboflavin, 0.983 mg (7%) niacin, 0.273 mg (5%) pantothenic acid, 0.138 mg (11%) vitamin B6, 19 µg (5%) folic acid, 835 µg (10.4%) vitamin A, 5.9 mg (7%) vitamin C, 0.66 mg (4%) vitamin E, and 13.2 µg (13%) vitamin K [1].

The production of carrot in Indonesia for the last 5 years increased from 495,800 tons in 2014 to 537,526 tons in 2016 and 609,634 tons in 2018. In West Nusa Tenggara (WNT), carrot production was decreased from 2,149 tons in 2014 to 1,422 tons in 2015, and then increased to 2,567 tons in 2016, but decreased again to 2,153 tons in 2018 [2]. On the other hand, the demand for carrot is predicted to increase, due to an increase in Indonesian population of 1.52% per annum [2], development of WNT as tourism destination and increase nutrition awareness. Therefore, there is a need to increase carrot

production in Indonesia, and this may be achieved by extending crop production to the lower lands, since the availability of high lands in Indonesia is limited.

Carrot is sub-tropical crop, and in Indonesia carrot is commonly cultivated in the mountainous of high latitudes areas, at which suitable temperature for optimal growth and productivity can be obtained. Carrot plants require optimal temperature of 18^0C to 24^0C for optimal growth and yield [3]. Exposure of carrot plant to temperature above 30^0C will decrease the plant growth, yield and quality of harvested carrot roots such as decreasing carotenoid contents, lignification of stele and production of branched roots [3,4]. Several varieties of carrots were reported to be able to be grown and produce edible roots in lower latitudes, such as the Kuroda and the Nantes varieties [5,6] as well as the Indonesian local variety of Gundaling [7]. However, the yield and yield quality of carrot produced in lower latitudes was still lower than the yield potential. Thus, there is a need to develop suitable cultivation technology, to alter growth and yield of carrot in lower latitudes, and one alternative is by improving physiological responses of carrot plants in lower latitudes of higher temperature by plant growth substances, such as biofertilizer.

2. Materials and method

Three separate experiments were undertaken in three different locations of different latitudes. The first experiment was conducted in Setiling Village of Central Lombok at altitudes of *ca.* 650 m above sea level (asl), the second experiment was in Beririjarak Village of East Lombok at altitudes of *ca.* 550 asl and the third experiment was in Rumbuk Village of East Lombok at *ca.* 175 m asl. The first and second experiment were comprised of ten experimental plots of 1 m x 2 m, comprising of 5 replicated plots per treatment. In experiment three, the treatment was comprised of ten replications planted in pot of 25 cm x 30 cm (w x h) contained the mixture of chicken manure, rice husk charcoal and top soil (1:1:1, v/v/v). The growing condition for each experiments is presented in Table 1.

Table 1. Comparison of growing condition for each experiment in this study.

Growing Condition	Experiment sites		
	Setiling (ca. 650 m asl)	**Beririjarak (*ca*. 550 m asl)**	**Rumbuk (*ca*. 175 m asl**
Experiment Plot	Planting bed of 1 m x 2 m	Planting bed of 1 m x 2 m	polybag of 25 cm x 30 cm
Planting space	20 cm x 20 cm	20 cm x 20 cm	As the length of polybag
Fertilization	Chicken manure, 4 kg per planting bed	Chicken manure, 4 kg per planting bed	Chicken manure, 1 part of planting mixture
Pest & Disease Control	Using pest traps, and application of *Metarhizium anisopliae* and *Beuveria basiana* (every week, alternately).	Using pest traps, and application of *Metarhizium anisopliae* and *Beuveria basiana* (every week, alternately).	Using pest traps, and application of *Metarhizium anisopliae* and *Beuveria basiana* (every week, alternately).
Biofertilizer applied	ExtraGEN	ExtraGEN	Bio-EXTRIM

Parameters used to investigate plant growth were plant height (measured at 10 weeks after planting), number of leaves (measured at 10 weeks after planting), leaves fresh and dry biomass (measured after harvest) while parameters used to evaluate yield and yield quality were yield per plant and yield per m^2, length of harvested carrot, width of harvested carrot (average with of top, middle and bottom parts), carrot strength and carrot sweetness.

All data were analyzed according to Analysis of Variance (Anova) at 5 % confidential level followed by Honestly Significant Difference (HSD/Turkey Multiple Range Comparison) at the same confidential level for parameters that were significantly difference according to Anova test.

3. Results and discussion

Growth and yield of carrot were differentially affected by biofertilizer application depending on the latitudes of cultivation. At a higher latitudes of 650 and 550 m asl, application of biofertilizer ExtraGEN affected several growth and parameters of carrot plants including plant height, the number of leaves, yield (fresh and dry weigh of harvested carrot), carrot diameter and degree of sweetness. However, in

low altitude of 170 asl, application of biofertizer Bio-EXTRIM did not affect growth and yield of carrot, except for the degree of carrot sweetness (Table 2).

Table 2. The effect of biofertilizer on growth and yield parameters of carrot cultivated at three different land latitudes.

Parameter	Location (cultivation latitudes)		
	Beririjarak (at *ca*. 650 m asl)	**Setiling (at *ca*. 550 m asl)**	**Rumbuk (at *ca*. 170 m asl)**
Plant height	S[*)]	S	NS[8)]
Number of leaves	S	S	NS
Yield/m2 (g)	S	S	NS
Fresh weight of leaves	NS	NS	NS
Dry weight of harvested carrot/m^2	S	S	NS
Dry weight of leaves	NS	NS	NS
Length of carrot	NS	NS	NS
Carrot diameter	S	S	NS
Softness	NS	NS	NS
Sweetness	S	S	S

[*)] S: Significantly different, NS Non-significantly different according to analysis of variance at 5% confidential level.

Growth and yield of carrot plants in different latitudes treated with and without biofertilizer are presented in Table 3 to Table 8.

Table 3. Growth of carrot plants as affected by biofertilizer ExtraGEN application at Beririjarak (at 550 m asl).

Treatment	Plant Height (cm)	Number of leaves	Fresh weight of leaves (g)	Dry weight of leaves (g)
No ExtraGEN	55.1 b[*]	13.0	121.2	19.3
With ExtraGEN	59.5 a	15.5	146.8	19.6
HSD 5%	4.20	1.20	-	-

[*]Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

As shown in Table 3, the biofertilizer treated carrot plants had a higher growth than control plants (no biofertilizer application) when cultivated in medium latitude of 550 m asl. The biofertilizer treated plants showed significantly taller plant and higher number of leaves, however all plants had no significantly different fresh and dry weight of leaves.

Table 4. Yield of carrot plants as affected by biofertilizer ExtraGEN application at Beririjarak (at 550 m asl).

Treatment	Yield/m^2 (g)	Carrot length (cm)	Carrot diameter (cm)	Carrot Softness (kg/cm^2)	Carrot sweetness (°Brix)
No ExtraGEN	2772.21a[*]	19,3	3,6 a	2,3	8.4a
With ExtraGEN	31 99.35b	19,6	4,5b	2,1	9.4b
HSD 5%	154.32	-	0,54	-	0.75

[*]Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

The carrot plants treated with biofertilizer had significantly higher yield, root diameter and sweetness. However, biofertilizer application did not significantly affect carrot length and softness, when cultivated in medium altitude of 550 m asl.

Table 5. Growth of carrot plants as affected by biofertilizer ExtraGEN application at Setiling (at 650 m asl).

Treatment	Plant Height (cm)	Number of leaves	Fresh weight of leaves (g)	Dry weight of leaves (g)
No ExtraGEN	50.2 a*	12,4 a	98.4	15,3
With ExtraGEN	55,6 b	14,5 b	104.6	15.9
HSD 5%	4.71	1,41	-	-

*Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

Table 6. Yield of carrot plants as affected by biofertilizer ExtraGEN application at Setiling (at 650 m asl).

Treatment	Yield/m2 (g)	Carrot length (cm)	Carrot diameter (cm)	Carrot Softness (kg/cm^2)	Carrot sweetness (°Brix)
No ExtraGEN	2147.3 a*	17.5	3.4 a	3.1	8.8 a
With ExtraGEN	2432.7 b	18.2	3.9 b	2.9	9.1 b
HSD 5%	172.4	-	0.48	-	0.62

*Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

The effect of biofertilizer to growth and yield of carrot cultivated in medium altitude of 650 m asl was similar to those in 550 m asl. The plants treated with biofertilizer had significantly taller plants and higher number of leaves (Table 5). In addition, the biofertilizer treated plants had a higher yield, wider diameter and sweeter than the control (untreated) plants (Table 6).

Table 7. Growth of carrot plants as affected by biofertilizer BIOEXTRIM application at Sakra (at 170 m asl).

Treatment	Plant Height (cm)	Number of leaves	Fresh weight of leaves (g)	Dry weight of leaves (g)
No ExtraGEN	48.5	10.4	78.4	12.3
With ExtraGEN	52.3	11.2	72.5	11.8

Table 8. Growth of carrot plants as affected by biofertilizer Bio-EXTRIM application at Sakra (at 170 m asl).

Treatment	Yield/plant (g)	Carrot length (cm)	Carrot diameter (cm)	Carrot Softness (kg/cm^2)	Carrot sweetness (°Brix)
No ExtraGEN	94.7	15,6	2.9	3.2	9.6 a*
With ExtraGEN	92.7	15.8	2.8	3.4	10.3 b
HSD 5%	-	-	-	-	1.14

*Means at each column followed by the same letter were not significantly different based on the HSD test at 5% significance level.

Table 7 and Table 8showed that in low land of 170 m asl, the biofertilizer treated and untreated plants showed no significant different in growth and yield. However, the biofertilizer treated plants was sweeter than control plants when cultivated in low land.

The data presented in this paper suggested that growth and yield of carrot in medium latitudes (at 650 and 550 m asl) were affected by biofertilizer applications. In the medium latitudes, application of biofertilizer ExtraGen significantly increased the growth and yield of carrot plants. In low land,

however, growth and yield of carrot plant did not significantly influenced by application of biofertilizer Bio-EXTRIM, except for the degree of sweetness.

Initially, it was hypothesized that biofertilizer will enhance growth and yield of carrot in medium and low lands, at areas with a higher temperature than the highland, as biofertilizers used in this study are claimed to contain several macro- and micro-nutrients, beneficial microorganism such *as Azospirilium* sp., *Azetobacter* sp., *Bacillu*s sp. and *Pseudomonas* sp., and plant growth regulators including auxin, cytokinins and giberellin. *Azospirilium* sp., *Azotobacter* sp., *Bacillu*s sp. and *Pseudomonas* sp. are nitrogen-fixing or phosphate-solubilizing bacteria [8]. In addition, the microorganism in biofertilizers have capability to produce plant growth promoting substances [9]. Plant roots colonized by *Azotobacter* sp., *Rhizobium* sp.*, Pseudomonas fluorescence,* and *Bacillus subtilis* produce triptopane, the IAA precursor for IAA biosynthesis in bacteria [10]. They also produce cytokinin and giberellin [11]. The application of biofertilizers in this study was attempted in order to increase the beneficial microbial community in carrot rhizosphere, and thus increase nutrients availability as well as provide auxin and cytokinin to enhance carrot roots and yield. In the medium latitude, application of biofertilizer did enhance growth and yield of the carrot plant, however it has no significant effect in lowland particularly in the polybag planting system. This may be due to unfavorable environmental condition inside the polybag for the microbial growth. Asroh suggested that application of biological fertilizers to plants or soil surface may cause the microbes in these biological fertilizers did not able to survive due to unfavorable environmental conditions such as unavailability of easily digested food, high air temperature, low humidity, and thus the microbes did not develop and die [12].

4. Conclusion

The growth and yield of carrot plants were differentially influenced by biofertilizers in different land latitudes. In the medium latitudes of 650 and 550 m asl, application of biofertilizer ExtraGen increased carrot plant height, number of leaves, carrot yield, and carrot diameter. In low land, however, application of biofertilizer Bio=EXTRIM did not influence plant height, the number of leaves, leaves fresh and dry biomass, carrot root yield, length and diameter. In addition, Biofertilizer increased the sweetness of carrot in medium and low latitudes.

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