

The Effect of Bio-Fertilizers on Plant Growth and Growth Rate of Grafted Avocado (*Persea americana* Mill.)

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Abstract— Avocado (*Persea americana* Mill.) is considered the most nutritious of all fruits. Avocado fruit contain high unsaturated fat, protein, and energy. It could be eaten fresh for food, drinks, cooking, and cosmetics. Recently, it has become a significant commodity in international trade. Indonesia is the 2nd avocado producing country, but only little quantity of avocado fruits could be exported. The farmers usually grow avocado plants from the seeds, without proper fertilizers in their backyards or small gardens. The problems could be solved by using grafted plants, proper fertilizers, and growing in a large scale of areas. This research was conducted to find out the effect of two liquid bio-fertilizers namely Mega Rhizo and Beyonic StarTmik on the plant growth and growth rate of grafted avocado plants. Some plant growths and growth rates of grafted avocado were influenced significantly by genotype accession, kind of bio-fertilizer, and weather (temperature). Plant growth and growth rate of most avocado accessions were not significant differences to bio-fertilizer applications, but some avocado accessions on certain months were significant differently. Growth rate ranks of plant height based on accession were no. 10, 28, 13, 1, 5, 2, and 14 consecutively. Those of canopy width were no. 28, 10, 1, 2, 14, 5, and 13 consecutively. Those of trunk diameters were no. 28, 10, 2, 5, 1, 13, and 14 consecutively. All growth rate ranks based on bio-fertilizer were Mega Rhizo, Beyonic StarTmik, and control consecutively.

Keywords— Grafted avocado; bio-fertilizer; Mega Rhizo; Beyonic StarTmik; plant growth; growth rate.

I. INTRODUCTION

Avocado belongs to Lauraceae family, originated from lowland and highland of meso-America, which cover West India, Guatemala, and Mexico regions. The native habitat of West Indian avocado is lowland, hot, and humid Central American forests with a short dry season; Guatemalan avocado is a tropical highland with year-round cool conditions; Mexican avocado is the most elevated (1400 – 2500 m), temperatures 14.2 – 19.80C, rainfall 665 – 1562 mm, and 6 – 8 months winter-spring dry period. Recognition of nutritional value of avocado fruit caused colonizers of the America to distribute this crop to new climate permitted regions [1].

FAOSTAT Database stated that avocado production increased rapidly in the world, the avocado was introduced to Indonesia by 1750 [1]. It was brought into Indonesia by Spanish merchants, cultivated using seedlings in home gardens of mountain regions [4]. Indonesia produced avocado 294,200 metric tons, which was the 2nd in the

world after 1st Mexico (1,316,104 metric tons) in 2012, but Indonesia did not recorded as avocado exporter country because of very small volume [5].

Avocado growth and production require 13 essential elements. These elements are divided three groups based on the relative amount required by avocado plant. The primary nutrients required are nitrogen, phosphorus, and potassium. The secondary nutrients required are calcium, magnesium and sulfur. The micro-nutrients required are zinc, iron, manganese, copper, boron, molybdenum, and chlorine [6]. Avocado plants require basic fertilizers, such as manure, inorganic fertilizers (urea, TSP, KCl), also micro-nutrients. Application of inorganic fertilizer could cause a pollution of soil, water, expensive cost, also do not have micro-nutrient; whereas application of bio-fertilizer could increase activated respiration and enzymatic of plant roots, supply nutrients and plant hormones for plant growth [7], [8], [9], [10], also substitute some amount of inorganic and decrease production cost [11], [12].

Our experiment used Mega Rhizo and Beyonic StarTmik liquid bio-fertilizers. Mega Rhizo fertilizer contains 200 g/l

C organic, 0.25 g/l N total, 0.1 g/l P₂O₅, 1 g/l K₂O, 0.1 g/l Ca, 52 mg/l Fe, 0.27 mg/l Mn, 0.33 mg/l Cu, 0.15 mg/l Zn, and 1.97 mg/l B, also micro-organisms of *Aspergillus niger*, *Lactobacillus* sp., *Actinomycetes* sp., *Streptomyces*, and *Acetobacter* [13]. Beyonic StarTmik bio-fertilizer contains 106 - 107 number of micro-organisms (*Bacillus*, *Pseudomonas*, *Painibacillus*, and *Burkholderia*), dissolved phosphate, tied up with nitrogen, hormones producer (IAA, cytokinin, gibberelin), and bio-control, also improve soil's health, boost the plant's growth, increase plant production [14], [15]. The aims of this experiment were to know the affect of bio-fertilizers to plant growth and grow rate of seven accessions of grafted avocado plants in the field.

II. METHODOLOGY

There are 630 of grafted avocado plants consisted of seven accessions (1, 2, 5, 10, 13, 14, 28) grown in Cibinong Science Center, Bogor since October 2011. Cibinong Science Center where located experiment is low elevated (207 m), temperatures 24.6 – 26.40C, month rainfall 201 – 702 mm with 19 – 87 days rain, air humidity 78 – 89%, and light intensity 201 – 356 cal/cm² from January 2013 until April 2014 [2]. The analysis of soil before treatment were texture consisted of 83% lime, 15% dust, and 2% sand; soil pH (H₂O) low (5), Ca 7.97 (very low), Mg 0.97 (low), K 0.04 (very low), Na 0.06 (very low), and KTK 16.37 (low) [3].

Basic fertilizers of 10 kg manure and 100 g NPK (15:15:15) were applied on soil where grafted avocado would be planted. The basic fertilizers of 10 kg manure and 200 g NPK were applied on each plant every six months. The experiment was carried out from October 2012 until April 2014. The experiment was arranged in randomized complete design. The treatments consisted of three application (two fertilizers and control) and seven accessions. Each accession consisted of three replications and each replication consisted of seven plants. The plant number of this experiment was 147 plants. Twelve month-old plants were applied with/ without two kinds of liquid bio-fertilizer, namely Mega Rhizo, Beyonic StarTmik, and control. Mega Rhizo fertilizer was applied every three months as recommended dosage, namely 120 times dilution and 3 liter for each plant for 4 times. Beyonic StarTmik fertilizer was applied every month as recommended dosage, namely 100 times dilution and 0.5 liter for each plant for 12 times.

Observation was conducted every two months, started on 5th month until 17th month after bio-fertilizers application in October 2012. The parameters of observation covered measuring plant growth (plant height, canopy width, trunk diameter) and growth rate (rank based on accession and fertilizer). Plant height was measured from soil surface to highest shoot, canopy width was measured from the longest canopy plant, and trunk diameter was measure from soil surface to 20 cm of the plant trunk. Growth rate was measured from plant growth of the month was subtracted by previous month and divided by previous month. Rank of growth rate based on accession was measured from average of growth rate of each accession, whereas based on fertilizer was measured from average of growth rate of fertilizer application. Data was analyzed with ANOVA procedures of

SPSS, means comparison was continued analyzed with Duncan's Multiple Range Test based on $\alpha = 5\%$.

III. RESULTS AND DISCUSSION

Grafted avocado plants treated with bio-fertilizers showed differently on plant growth and growth rate of each accession. Most application of bio-fertilizers did not affect significantly on plant growth and growth rate of avocado plants, only a few of the accessions could increase their growth and grow rate on certain months of observation. Soil analysis showed most nutrients content of the soil increased after eleven months bio-fertilizer application [16].

A. Plant height

1) *Plant Growth*: The growth of plant height treated with liquid fertilizers showed differently each accession. Plant height accession no. 2 was significant different on 7th, 9th, and 11th months. The highest plant height was treated by Mega Rhizo fertilizer (199.85 cm), followed by Beyonic StarTmik (165.50 cm) and control (164.00 cm) on 7th, until 247.29 cm, 212.43 cm, and 199.71 cm on 11th month consecutively (Table I). Plant height accession no. 13 was significant different since on 9th until 17th months. The highest plant height was treated by Mega Rhizo fertilizer (183.43 cm), followed by Beyonic StarTmik (168.86 cm) and control (143.67) on 9th month until 269.71, 222.57, 205.83 cm on 17th month consecutively (Table I). Plant heights of other accessions (no. 1, 5, 10, 14, 28) were not significantly different among fertilizer treatments and control (Table I).

These results stated that genotype of avocado plants affected their responses to the bio-fertilizers. Avocado accession no. 13 was the most responses to application of Mega Rhizo fertilizer, which showed the highest plant height compared to those of Beyonic StarTmik and control on 9th to 17th months. Avocado accession no. 2 also had same responses to the Mega Rhizo and Beyonic StarTmik bio-fertilizers but only on 7th to 11th months. Cultivars and rootstocks of avocado influenced nutrients absorption for plant growth [17]. Beyonic StarTmik also increased plant height of water melon (*Citrullus lanatus*) [10]. Mega Rhizo or Beyonic StarTmik increased plant growth, yield, and decreased applying in-organic fertilizer on maize [11].

2) *Growth Rate*: different on 7th month. The highest growth rate was treated by Mega Rhizo fertilizer (0.123 cm), followed by control (0.060 cm) and Beyonic StarTmik (0.055 cm) (Table II). Growth rate accession no. 17 was significant different on 7th month. The highest growth rate was treated Beyonic StarTmik fertilizer (0.089 cm), followed by Mega Rhizo (0.080 cm) and control (0.066 cm) consecutively (Table II). Growth rate accession no. 1 was significant different on 5th month. The highest growth rate was treated by control (0.183 cm), followed by Mega Rhizo fertilizer (0.120 cm), and Beyonic StarTmik (0.094 cm) consecutively (Table II). These results showed that weather and plant genotype affected on growth rate of plant height. Avocado accession no. 1 responded to plant genotype, which control showed the highest growth rate on 5th month, whereas accession no. 2 were the highest growth rate with application of Mega Rhizo fertilizer on 7th month. On the

other hand, avocado accession no. 14 was the highest growth rate with application of Beyonic StarTmik fertilizer on 7th month. The rank (from the highest to the slowest) of growth rate of plant height based on accession was no. 10, 28, 13, 1, 5, 2, and 14 consecutively (Table III), whereas those of based on fertilizer application was Mega Rhizo, Beyonic StarTmik, and control consecutively (Table III).

B. Canopy width

1) Plant Growth:

The growth of canopy width showed did not significantly different treated with liquid fertilizers for all accessions, except of accession no. 13. Canopy growth of accession no. 13 showed differently on 11th until 17th month. The canopy widest was treated with Mega Rhizo fertilizer (155.29 cm), followed by Beyonic StarTmik fertilizer (145.86 cm), and control (120 cm) consecutively on 11th month. The canopy widest was treated (189.71), followed by Beyonic StarTmik (172.86 cm) and control (147.67 cm) consecutively on 17th month (Table IV). There was a different rank of canopy width only of the accession plants no 13 started on 11th month. It could be caused by different genotype of plant that responded differently to the bio-fertilizer applied.

2) *Growth Rate:* The growth rate of canopy width showed significantly different treated with liquid fertilizers on three accessions but occurring sporadic. Avocado accession no. 14 showed significantly different on 17th month. The fastest growth rate of canopy width was treated Beyonic StarTmik (0.071 cm), followed by Mega Rhizo fertilizers (0.064 cm) and control (0.007 cm) (Table V). Avocado accession no. 13 showed significantly different on 7th and 15th months. The fastest growth rate of canopy width was Mega Rhizo fertilizer (0.130 cm), followed by control (0.080 cm) and Beyonic StarTmik fertilizer (0.076 cm) on 7th month; whereas on 15th month, the fastest of growth rate was control (0.065 cm), followed by Mega Rhizo fertilizer (0.051 cm) and Beyonic StarTmik fertilizer (0.047 cm) (Table V). Avocado accession no. 10 showed significantly different on 17th month. The fastest on growth rate was Mega Rhizo fertilizer (0.087 cm), followed by control (0.073 cm) and Beyonic StarTmik fertilizer (0.060 cm) (Table V). The rank (from the highest to the slowest) of growth rate of canopy width were accession no. 28, 10, 1, 2, 14, 5, and 13 consecutively (VI), whereas those of based on fertilizer application was Mega Rhizo, Beyonic StarTmik, and control consecutively (Table VI). Mega Rhizo was better than Beyonic StarTmik fertilizer because Mega Rhizo content micronutrients of Fe and Zn that required highly by avocado plant [13], [18].

C. Trunk Diameter

1) *Plant Growth:* The growth of trunk diameter were not significant different, except accession no. 13. The significant differently of trunk diameter growth began on 9th until 17th months. The widest trunk growth was Mega Rhizo fertilizer (44.29 mm), followed by Beyonic StarTmik (40.64 mm) and control (34.00 mm) on 9th month consecutively until 54.71, 50.42, 41.50 on 17th month consecutively (Table VII). These results showed that only plant genotype accession no. 13 was the most response to the bio-fertilizer.

Mega Rhizo fertilizer treatment was more response than Beyonic StarTmik for trunk diameter of avocado plant.

2) *Growth Rate:* The growth rate of trunk diameter showed significantly different on 7th month of accession no. 10, 13, and 14. The fastest of growth rate of accession no. 10 was Beyonic StarTmik (0.161 mm), followed by control (0.128 mm) and Mega Rhizo fertilizers (0.089 mm) consecutively (Table VIII). The fastest of growth rate of accession no. 13 was Beyonic StarTmik (0.146 mm), followed by Mega Rhizo fertilizers (0.134 mm) and control (0.078 mm) consecutively (Table VIII). The fastest of growth rate of accession no. 14 was Mega Rhizo fertilizer (0.160 mm), followed by Beyonic StarTmik (0.097 mm) and control (0.051 mm) consecutively (Table VIII). These results showed the genotype of plant avocado affected primarily to growth rate of trunk diameter. The analysis of soil sample showed an application of Mega Rhizo fertilizer also increased significantly nitrogen content (0.17% to 0.24%) in soil, which could increase growth rate of trunk diameter. The weather also affected to growth rate of trunk diameter accession no. 14, 13, and 10 that significantly differences occurred on 7th month. The temperatures of 7th month (May 2013) and one month before (April 2013) were the highest (26.2 - 26.40C) compared to other months on experimental location. Climatic conditions influenced nutrients absorption for growth rate of avocado [17]. The rank (from the highest to the slowest) of growth rate of trunk diameter was accession no. 28, 10, 2, 5, 1, 13, and 14 (Table IX), whereas those of based on fertilizer application was Mega Rhizo, Beyonic StarTmik, and control consecutively (Table IX).

IV. CONCLUSIONS

Application of bio-fertilizers affected differently on plant growth and growth rate of grafted avocado. Plant growth and growth rate of grafted avocado were influenced by genotype accession, kind of bio-fertilizer, and weather (temperature). Plant growth of most avocado accessions was not significant differences to bio-fertilizer application, but avocado accession no. 13 was significant different on 9th until 17th months. Some growth rate of avocado accession no. 14, 13, and 10 affected significantly on 7th month when high temperature occurred. The fastest growth rate based on accession was avocado accession no. 28, whereas based on bio-fertilizer was Mega Rhizo.

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APPENDIX

TABLE I
PLANT HEIGHT GROWTH (CM) OF GRAFTED AVOCADO FOR 17 MONTHS

Acc.	Treatment	Months After Bio-fertilizer Application						
		5	7	9	11	13	15	17
1	Control	303.57±82.60(a)	333.57±91.88(a)	365.14±95.52(a)	431.71±136.86(a)	464.00±133.92(a)	480.14±136.48(a)	495.14±134.24(a)
	Megarhizo	271.71±49.57(a)	306.86±40.15(a)	341.14±53.23(a)	393.29±62.89(a)	418.43±66.22(a)	447.29±63.52(a)	465.00±67.76(a)
	Beyonik	287.00±90.01(a)	329.60±109.44(a)	354.33±103.02(a)	412.83±139.98(a)	438.00±144.58(a)	450.17±144.97(a)	470.50±140.34(a)
2	Control	154.57±31.44(a)	164.00±30.60(a)	175.43±32.40(a)	199.71±36.84(a)	212.71±43.25(a)	224.14±44.24(a)	237.71±53.20(a)
	Megarhizo	175.43±30.02(a)	199.85±31.90(b)	216.43±38.74(b)	247.29±36.48(b)	258.00±37.61(a)	260.14±38.16(a)	283.29±39.22(a)
	Beyonik	155.83±12.01(a)	165.50±18.38(a)	191.57±24.15(ab)	212.43±25.47(ab)	224.29±41.71(a)	247.00±48.21(a)	267.00±48.63(a)
5	Control	152.43±34.65(a)	167.29±40.68(a)	182.14±48.36(a)	203.43±55.61(a)	224.86±51.09(a)	236.00±50.48(a)	253.57±52.70(a)
	Megarhizo	178.29±40.49(a)	192.57±45.00(a)	209.29±54.74(a)	246.57±62.33(a)	252.86±67.71(a)	266.14±67.57(a)	281.29±68.30(a)
	Beyonik	156.00±38.52(a)	168.00±51.59(a)	193.14±68.64(a)	208.86±66.02(a)	228.14±77.55(a)	241.71±77.08(a)	260.00±78.00(a)
10	Control	116.33±18.37(a)	130.17±19.31(a)	131.33±19.99(a)	145.83±23.75(a)	177.50±25.74(a)	191.50±26.46(a)	217.83±27.29(a)
	Megarhizo	123.86±12.81(a)	136.00±14.83(a)	147.14±31.78(a)	160.86±32.87(a)	185.00±43.65(a)	198.14±43.88(a)	222.57±50.62(a)
	Beyonik	118.43±17.32(a)	129.71±20.93(a)	138.00±27.47(a)	154.14±33.21(a)	189.00±27.36(a)	203.29±27.37(a)	223.71±29.66(a)
13	Control	118.67±29.95(a)	134.17±26.90(a)	143.67±26.01(a)	159.17±34.58(a)	177.17±38.74(a)	190.33±38.96(a)	205.83±40.09(a)
	Megarhizo	142.14±31.86(ab)	162.00±31.98(a)	183.43±28.79(b)	205.00±31.06(b)	226.14±35.42(b)	240.57±35.64(b)	269.71±62.21(b)
	Beyonik	150.57±17.79(b)	158.43±17.35(a)	168.86±19.20(ab)	179.86±17.62(ab)	192.86±26.53(ab)	207.00±26.75(ab)	222.57±28.23(ab)
14	Control	161.57±24.31(a)	173.00±23.72(a)	191.57±25.39(a)	205.71±32.38(a)	229.71±40.93(a)	241.86±41.41(a)	246.86±40.11(a)
	Megarhizo	157.83±26.22(a)	171.83±31.15(a)	184.71±37.49(a)	205.57±42.59(a)	230.86±40.37(a)	251.57±56.74(a)	258.14±39.30(a)
	Beyonik	159.86±26.51(a)	176.57±35.31(a)	195.43±45.92(a)	215.71±46.51(a)	238.85±51.51(a)	244.29±49.00(a)	256.29±49.84(a)
28	Control	97.43±20.72(a)	113.71±25.36(a)	123.86±25.31(a)	139.71±32.59(a)	147.86±30.84(a)	157.71±31.26(a)	172.86±30.71(a)
	Megarhizo	100.29±20.30(a)	115.29±18.25(a)	128.14±23.36(a)	143.57±25.10(a)	152.57±28.91(a)	163.29±30.21(a)	179.14±29.94(a)
	Beyonik	94.00±13.81(a)	108.57±17.02(a)	118.29±16.79(a)	136.00±22.82(a)	143.00±25.14(a)	154.14±23.08(a)	168.71±23.12(a)

Values represents means ± SE. Different letters in the same parameter data indicate significant differences by DUNCAN test ($p \leq 0.05$)

TABLE II
GROWTH RATE (CM/MONTH) OF PLANT HEIGHT OF GRAFTED AVOCADO

Acc.	Treatment	Months After Bio-fertilizer Application						
		5	7	9	11	13	15	17
1	Control	0.183±0.070(b)	0.086±0.034(a)	0.090±0.044(a)	0.139±0.085(a)	0.074±0.046(a)	0.036±0.011(a)	0.033±0.024(a)
	Megarhizo	0.120±0.057(ab)	0.119±0.068(a)	0.094±0.046(a)	0.131±0.049(a)	0.057±0.072(a)	0.066±0.078(a)	0.039±0.009(a)
	Beyonik	0.094±0.052(a)	0.122±0.041(a)	0.238±0.376(a)	0.130±0.048(a)	0.057±0.038(a)	0.028±0.008(a)	0.048±0.033(a)
2	Control	0.087±0.061(a)	0.060±0.024(a)	0.063±0.046(a)	0.117±0.079(a)	0.057±0.053(a)	0.050±0.016(a)	0.054±0.026(a)
	Megarhizo	0.103±0.063(a)	0.123±0.046(b)	0.073±0.052(a)	0.126±0.072(a)	0.040±0.052(a)	0.001±0.133(a)	0.083±0.036(a)
	Beyonik	0.130±0.057(a)	0.055±0.055(a)	0.259±0.329(a)	0.094±0.072(a)	0.041±0.087(a)	0.087±0.090(a)	0.076±0.036(a)
5	Control	0.129±0.072(a)	0.084±0.034(a)	0.074±0.054(a)	0.101±0.059(a)	0.104±0.063(a)	0.050±0.020(a)	0.069±0.011(a)
	Megarhizo	0.147±0.053(a)	0.073±0.032(a)	0.067±0.067(a)	0.139±0.129(a)	0.004±0.247(a)	0.056±0.021(a)	0.059±0.022(a)
	Beyonik	0.130±0.065(a)	0.051±0.926(a)	0.113±0.088(a)	0.087±0.063(a)	0.074±0.056(a)	0.064±0.029(a)	0.077±0.021(a)
10	Control	0.188±0.122(a)	0.105±0.072(a)	0.003±0.123(a)	0.097±0.052(a)	0.178±0.074(a)	0.075±0.014(a)	0.118±0.081(a)
	Megarhizo	0.151±0.091(a)	0.087±0.046(a)	0.050±0.154(a)	0.089±0.081(a)	0.120±0.080(a)	0.071±0.015(a)	0.103±0.084(a)
	Beyonik	0.157±0.139(a)	0.086±0.042(a)	0.053±0.071(a)	0.101±0.057(a)	0.187±0.082(a)	0.071±0.012(a)	0.093±0.019(a)
13	Control	0.080±0.116(a)	0.115±0.086(a)	0.067±0.042(a)	0.092±0.040(a)	0.102±0.055(a)	0.070±0.015(a)	0.077±0.012(a)
	Megarhizo	0.169±0.065(a)	0.116±0.143(a)	0.117±0.102(a)	0.103±0.064(a)	0.091±0.062(a)	0.061±0.011(a)	0.093±0.097(a)
	Beyonik	0.127±0.059(a)	0.051±0.029(a)	0.061±0.011(a)	0.061±0.036(a)	0.061±0.052(a)	0.070±0.008(a)	0.070±0.008(a)
14	Control	0.103±0.064(a)	0.066±0.033(a)	0.099±0.032(a)	0.066±0.024(a)	0.097±0.080(a)	0.049±0.013(a)	0.019±0.083(a)
	Megarhizo	0.163±0.034(a)	0.080±0.049(b)	0.213±0.351(a)	0.101±0.034(a)	0.110±0.053(a)	0.074±0.062(a)	0.034±0.079(a)
	Beyonik	0.106±0.061(a)	0.089±0.060(ab)	0.090±0.047(a)	0.094±0.046(a)	0.071±0.258(a)	0.009±0.181(a)	0.047±0.026(a)
28	Control	0.184±0.098(a)	0.139±0.046(a)	0.083±0.061(a)	0.109±0.065(a)	0.059±0.053(a)	0.064±0.019(a)	0.089±0.020(a)
	Megarhizo	0.147±0.109(a)	0.131±0.100(a)	0.099±0.046(a)	0.054±0.087(a)	0.054±0.040(a)	0.067±0.021(a)	0.090±0.017(a)
	Beyonik	0.177±0.072(a)	0.131±0.039(a)	0.081±0.062(a)	0.049±0.083(a)	0.049±0.031(a)	0.076±0.033(a)	0.089±0.028(a)

Values represents means ± SE. Different letters in the same parameter data indicate significant differences by DUNCAN test (p≤0.05)

TABLE III
GROWTH RATE (CM/MONTH) OF PLANT HEIGHT BASED ON BIO-FERTILIZER AND ACCESSION NUMBER

Treatment	Accession No.							Average	Rank
	1	2	5	10	13	14	28		
Control	0.106	0.079	0.097	0.130	0.094	0.080	0.117	0.100	3
Megarhizo	0.100	0.089	0.094	0.113	0.128	0.101	0.115	0.106	1
Beyonic	0.091	0.108	0.099	0.122	0.079	0.088	0.118	0.101	2
Average	0.099	0.092	0.097	0.121	0.100	0.090	0.117		
Rank	4	6	5	1	3	7	2		

TABLE IV
CANOPY WIDTH GROWTH (CM) OF GRAFTED AVOCADO FOR 17 MONTHS

Acc.	Treatment	Months After Bio-fertilizer Application						
		5	7	9	11	13	15	17
1	Control	207.43±65.43(a)	236.29±69.73(a)	272.00±88.87(a)	338.00±129.84(a)	362.86±128.28(a)	383.57±106.20(a)	395.86±105.27(a)
	Megarhizo	183.86±26.53(a)	205.71±32.14(a)	232.86±39.07(a)	278.57±45.89(a)	310.43±54.95(a)	346.00±66.57(a)	361.29±67.18(a)
	Beyonik	201.17±40.32(a)	232.83±62.00(a)	265.17±87.91(a)	306.67±96.11(a)	327.00±90.30(a)	344.83±73.29(a)	361.83±69.78(a)
2	Control	112.57±19.75(a)	127.14±32.89(a)	140.00±29.92(a)	152.43±31.04(a)	165.43±43.23(a)	175.86±43.31(a)	185.14±46.24(a)
	Megarhizo	113.00±16.24(a)	126.29±27.61(a)	144.86±25.10(a)	159.00±28.45(a)	169.43±32.89(a)	177.29±32.99(a)	200.00±37.53(a)
	Beyonik	118.43±22.50(a)	127.29±19.70(a)	141.57±15.03(a)	151.86±28.63(a)	165.86±30.85(a)	173.71±32.67(a)	194.14±33.00(a)
5	Control	158.29±26.29(a)	178.43±33.30(a)	181.00±34.34(a)	201.14±40.36(a)	219.71±43.91(a)	230.57±45.21(a)	245.43±44.17(a)
	Megarhizo	185.29±28.87(a)	208.43±36.85(a)	227.14±45.60(a)	245.57±49.66(a)	269.00±43.28(a)	277.14±43.98(a)	294.29±43.27(a)
	Beyonik	156.43±47.40(a)	177.57±60.89(a)	187.43±68.95(a)	213.00±76.77(a)	233.57±78.81(a)	240.43±80.02(a)	257.86±83.97(a)
10	Control	103.00±11.01(a)	125.00±19.37(a)	135.17±18.32(a)	146.17±14.68(a)	185.17±30.33(a)	193.83±29.55(a)	209.50±33.76(a)
	Megarhizo	111.14±19.00(a)	131.43±20.16(a)	141.43±21.59(a)	156.00±29.97(a)	192.00±28.80(a)	201.71±29.76(a)	220.29±29.54(a)
	Beyonik	116.14±21.63(a)	131.29±22.46(a)	144.71±26.76(a)	158.14±37.08(a)	185.57±36.77(a)	192.71±40.26(a)	205.14±44.15(a)
13	Control	106.29±17.23(a)	112.17±20.32(a)	117.17±20.23(a)	120.00±25.59(a)	129.17±27.31(a)	138.17±28.07(a)	147.67±29.64(a)
	Megarhizo	114.00±17.37(a)	131.43±19.36(a)	140.43±16.11(a)	155.29±21.45(b)	167.71±32.03(b)	176.71±32.08(b)	189.71±31.61(b)
	Beyonik	123.43±20.95(a)	133.14±20.29(a)	140.71±19.70(a)	145.86±21.03(ab)	159.57±21.33(ab)	168.00±23.68(ab)	172.86±33.85(ab)
14	Control	139.00±18.78(a)	149.57±16.02(a)	164.14±15.16(a)	186.71±15.13(a)	205.14±24.59(a)	214.71±26.58(a)	218.71±39.72(a)
	Megarhizo	132.43±21.24(a)	142.86±19.81(a)	157.86±23.70(a)	177.86±25.18(a)	193.00±28.14(a)	203.71±30.16(a)	218.00±34.43(a)
	Beyonik	134.14±27.85(a)	149.43±29.17(a)	174.00±48.95(a)	189.86±52.95(a)	205.71±52.24(a)	215.29±53.32(a)	232.57±60.34(a)
28	Control	68.14±11.16(a)	87.28±13.11(a)	98.71±15.64(a)	110.86±16.44(a)	117.14±17.05(a)	125.86±17.27(a)	139.57±17.87(a)
	Megarhizo	66.57±13.62(a)	86.86±15.87(a)	94.29±20.20(a)	110.57±12.15(a)	118.57±9.45(a)	128.43±9.95(a)	140.43±7.91(a)
	Beyonik	63.71±20.74(a)	82.57±16.37(a)	98.14±19.17(a)	110.43±13.99(a)	112.71±12.98(a)	120.57±12.55(a)	133.14±10.27(a)

Values represents means ± SE. Different letters in the same parameter data indicate significant differences by DUNCAN test (p≤0.05)

TABLE V
GROWTH RATE (CM/MONTH) OF CANOPY WIDTH OF GRAFTED AVOCADO

Acc.	Treatment	Months After Bio-fertilizer Application						
		5	7	9	11	13	15	17
1	Control	0.174±0.083(a)	0.123±0.107(a)	0.119±0.067(a)	0.164±0.120(a)	0.081±0.060(a)	0.077±0.138(a)	0.034±0.017(a)
	Megarhizo	0.163±0.110(a)	0.101±0.067(a)	0.114±0.054(a)	0.160±0.078(a)	0.096±0.089(a)	0.097±0.093(a)	0.043±0.008(a)
	Beyonik	0.088±0.044(a)	0.190±0.136(a)	0.108±0.080(a)	0.128±0.097(a)	0.067±0.051(a)	0.058±0.124(a)	0.050±0.022(a)
2	Control	0.094±0.116(a)	0.103±0.073(a)	0.096±0.090(a)	0.080±0.060(a)	0.069±0.051(a)	0.061±0.012(a)	0.049±0.050(a)
	Megarhizo	0.124±0.092(a)	0.091±0.107(a)	0.131±0.076(a)	0.083±0.098(a)	0.060±0.036(a)	0.044±0.013(a)	0.110±0.079(a)
	Beyonik	0.103±0.062(a)	0.073±0.063(a)	0.104±0.069(a)	0.056±0.089(a)	0.084±0.072(a)	0.044±0.019(a)	0.103±0.098(a)
5	Control	0.090±0.061(a)	0.107±0.068(a)	0.013±0.011(a)	0.099±0.034(a)	0.083±0.031(a)	0.050±0.006(b)	0.066±0.017(a)
	Megarhizo	0.060±0.063(a)	0.106±0.085(a)	0.074±0.078(a)	0.071±0.067(a)	0.091±0.081(a)	0.030±0.014(a)	0.059±0.038(a)
	Beyonik	0.101±0.081(a)	0.104±0.081(a)	0.036±0.106(a)	0.123±0.037(a)	0.091±0.089(a)	0.031±0.016(a)	0.071±0.034(a)
10	Control	0.177±0.069(a)	0.170±0.098(a)	0.075±0.060(a)	0.078±0.052(a)	0.202±0.077(a)	0.045±0.014(a)	0.073±0.024(ab)
	Megarhizo	0.199±0.079(a)	0.154±0.077(a)	0.067±0.062(a)	0.089±0.063(a)	0.187±0.085(a)	0.050±0.012(a)	0.087±0.020(b)
	Beyonik	0.231±0.120(a)	0.117±0.050(b)	0.090±0.061(a)	0.079±0.061(a)	0.147±0.084(a)	0.036±0.018(a)	0.060±0.012(a)
13	Control	0.136±0.148(a)	0.080±0.049(ab)	0.045±0.031(a)	0.017±0.042(a)	0.070±0.086(a)	0.065±0.019(b)	0.062±0.021(a)
	Megarhizo	0.126±0.073(a)	0.130±0.048(b)	0.063±0.110(a)	0.091±0.062(a)	0.067±0.090(a)	0.051±0.015(ab)	0.070±0.024(a)
	Beyonik	0.161±0.086(a)	0.076±0.031(a)	0.056±0.052(a)	0.294±0.085(b)	0.089±0.050(a)	0.047±0.010(a)	0.016±0.119(a)
14	Control	0.081±0.091(a)	0.071±0.051(a)	0.087±0.075(a)	0.119±0.063(a)	0.084±0.084(a)	0.044±0.011(a)	0.007±0.080(a)
	Megarhizo	0.106±0.060(a)	0.074±0.035(b)	0.091±0.050(a)	0.109±0.071(a)	0.073±0.098(a)	0.053±0.018(a)	0.064±0.020(ab)
	Beyonik	0.066±0.052(a)	0.103±0.041(a)	0.121±0.100(a)	0.081±0.057(a)	0.083±0.035(a)	0.046±0.014(a)	0.071±0.041(b)
28	Control	0.136±0.109(a)	0.216±0.106(a)	0.111±0.084(a)	0.104±0.108(a)	0.053±0.057(a)	0.070±0.024(a)	0.100±0.028(a)
	Megarhizo	0.210±0.120(a)	0.229±0.098(a)	0.070±0.104(a)	0.147±0.157(a)	0.070±0.055(a)	0.077±0.031(a)	0.086±0.036(a)
	Beyonik	0.090±0.367(a)	0.239±0.129(a)	0.146±0.155(a)	0.119±0.085(a)	0.019±0.076(a)	0.066±0.025(a)	0.096±0.033(a)

Values represents means ± SE. Different letters in the same parameter data indicate significant differences by DUNCAN test (p<0.05)

TABLE VI
GROWTH RATE (CM/MONTH) OF CANOPY WIDTH BASED ON BIO-FERTILIZER AND ACCESSION NUMBER

Treatment	Accession No.							Average	Rank
	1	2	5	10	13	14	28		
Control	0.132	0.09	0.081	0.133	0.07	0.082	0.135	0.103	3
Megarhizo	0.13	0.106	0.078	0.14	0.097	0.092	0.157	0.114	1
Beyonic	0.113	0.091	0.093	0.129	0.078	0.094	0.14	0.105	2
Average	0.125	0.095	0.084	0.134	0.082	0.89	0.144		
Rank	3	4	6	2	7	5	1		

TABLE VII
TRUNK DIAMETER GROWTH (MM) OF GRAFTED AVOCADO FOR 17 MONTHS

Acc	Treatment	Months After Bio-fertilizer Application						
		5	7	9	11	13	15	17
1	Control	47.71±12.08(a)	57.00±7.62(a)	62.71±11.24(a)	74.57±17.27(a)	79.29±19.59(a)	79.29±19.59(a)	80.29±19.77(a)
	Megarhizo	47.86±5.27(a)	56.29±6.99(a)	63.14±8.93(a)	69.43±10.52(a)	75.71±13.61(a)	75.71±13.61(a)	77.43±13.02(a)
	Beyonik	51.00±11.47(a)	58.00±10.75(a)	67.33±13.52(a)	78.17±17.24(a)	82.67±18.35(a)	83.00±18.09(a)	84.00±18.09(a)
2	Control	31.86±5.05(a)	35.14±4.91(a)	39.13±6.31(a)	41.29±7.85(a)	43.71±8.50(a)	45.57±10.47(a)	49.14±13.47(a)
	Megarhizo	35.86±6.15(a)	40.43±8.24(a)	47.71±11.66(a)	50.71±11.34(a)	53.86±12.70(a)	57.57±14.71(a)	60.86±16.01(a)
	Beyonik	30.57±4.19(a)	36.14±3.72(a)	38.71±5.41(a)	43.57±5.80(a)	46.71±5.74(a)	49.71±7.67(a)	53.43±9.95(a)
5	Control	44.86±8.51(a)	51.00±10.10(a)	57.43±11.04(a)	62.57±13.14(a)	67.14±15.03(a)	67.29±15.05(a)	68.29±15.05(a)
	Megarhizo	51.71±7.99(a)	59.57±8.50(a)	65.86±9.79(a)	72.00±11.06(a)	76.71±14.36(a)	78.57±14.32(a)	79.43±14.27(a)
	Beyonik	43.86±13.93(a)	51.86±17.77(a)	59.00±21.38(a)	67.43±23.70(a)	70.00±25.85(a)	71.86±26.37(a)	72.57±26.54(a)
10	Control	26.83±4.54(a)	30.67±3.83(a)	33.67±4.80(a)	38.00±5.18(a)	44.00±7.48(a)	44.33±7.74(a)	45.17±7.65(a)
	Megarhizo	29.43±5.19(a)	32.43±5.91(a)	36.14±7.43(a)	39.00±7.28(a)	45.14±10.61(a)	45.71±10.58(a)	46.43±10.28(a)
	Beyonik	27.71±5.74(a)	32.86±5.64(a)	37.29±6.82(a)	40.29±8.34(a)	46.71±7.48(a)	46.86±7.36(a)	47.71±7.39(a)
13	Control	28.83±5.78(a)	31.33±6.19(a)	34.00±5.90(a)	37.17±6.31(a)	40.00±8.15(a)	40.50±7.97(a)	41.5±7.97(a)
	Megarhizo	32.43±6.16(a)	37.43±6.95(a)	44.29±9.18(b)	48.29±8.32(b)	53.57±11.86(b)	54.00±11.40(b)	54.71±11.32(b)
	Beyonik	31.14±5.43(a)	36.43±6.11(a)	40.64±5.85(ab)	44.86±6.82(ab)	49.29±8.94(ab)	49.57±8.98(ab)	50.43±8.81(ab)
14	Control	44.00±3.00(a)	46.86±6.07(a)	54.00±7.40(a)	60.14±9.48(a)	63.14±8.43(a)	65.00±6.40(a)	68.86±8.45(a)
	Megarhizo	42.43±7.11(a)	50.71±8.99(a)	55.21±9.29(a)	59.71±8.94(a)	65.57±9.50(a)	65.86±9.21(a)	66.86±9.21(a)
	Beyonik	45.29±8.98(a)	50.29±10.56(a)	56.00±12.56(a)	61.86±13.64(a)	67.57±16.51(a)	67.71±16.31(a)	68.71±16.31(a)
28	Control	21.00±3.06(a)	24.29±3.20(a)	28.14±4.67(a)	31.14±4.60(a)	32.57±3.51(a)	32.86±3.34(a)	33.71±3.15(a)
	Megarhizo	20.29±2.75(a)	24.57±4.54(a)	27.29±5.44(a)	32.43±4.76(a)	34.43±5.38(a)	34.71±5.28(a)	35.43±5.26(a)
	Beyonik	20.00±2.89(a)	23.29±4.61(a)	28.00±6.08(a)	31.00±4.62(a)	34.29±5.19(a)	34.29±5.19(a)	35.14±5.27(a)

Values represents means ± SE. Different letters in the same parameter data indicate significant differences by DUNCAN test (p≤0.05)

TABLE VIII
GROWTH RATE (MM/MONTH) OF TRUNK DIAMETER OF GRAFTED AVOCADO

Acc.	Treatment	Months After Bio-fertilizer Application						
		5	7	9	11	13	15	17
1	Control	0.167±0.142(a)	0.170±0.138(a)	0.076±0.133(a)	0.146±0.728(a)	0.056±0.032(a)	0.000±0.000(a)	0.011±0.007(a)
	Megarhizo	0.141±0.031(a)	0.149±0.034(a)	0.107±0.066(a)	0.089±0.389(a)	0.077±0.056(a)	0.000±0.000(a)	0.023±0.026(a)
	Beyonik	0.140±0.065(a)	0.123±0.042(a)	0.137±0.061(a)	0.135±0.046(a)	0.053±0.012(a)	0.003±0.005(a)	0.012±0.004(a)
2	Control	0.144±0.058(a)	0.096±0.045(a)	0.094±0.082(a)	0.044±0.097(a)	0.056±0.035(a)	0.033±0.033(a)	0.061±0.072(a)
	Megarhizo	0.189±0.061(a)	0.107±0.067(a)	0.146±0.049(a)	0.061±0.030(a)	0.057±0.043(a)	0.063±0.049(a)	0.053±0.035(a)
	Beyonik	0.177±0.038(a)	0.157±0.052(a)	0.140±0.175(a)	0.109±0.082(a)	0.069±0.050(a)	0.056±0.044(a)	0.063±0.039(a)
5	Control	0.171±0.056(a)	0.119±0.043(a)	0.111±0.047(a)	0.077±0.049(a)	0.063±0.049(a)	0.001±0.004(a)	0.014±0.005(a)
	Megarhizo	0.204±0.053(a)	0.136±0.030(a)	0.096±0.036(a)	0.083±0.040(a)	0.056±0.054(a)	0.021±0.052(a)	0.010±0.006(a)
	Beyonik	0.200±0.062(a)	0.144±0.047(a)	0.116±0.056(a)	0.124±0.073(a)	0.033±0.035(a)	0.026±0.044(a)	0.011±0.011(a)
10	Control	0.203±0.075(a)	0.128±0.053(a)	0.087±0.035(a)	0.110±0.088(a)	0.132±0.049(a)	0.007±0.010(a)	0.020±0.011(a)
	Megarhizo	0.253±0.072(a)	0.089±0.073(a)	0.100±0.037(a)	0.076±0.052(a)	0.130±0.047(a)	0.013±0.013(a)	0.016±0.011(a)
	Beyonik	0.204±0.051(a)	0.161±0.041(b)	0.117±0.024(a)	0.071±0.046(a)	0.143±0.039(a)	0.003±0.008(a)	0.017±0.008(a)
13	Control	0.187±0.089(a)	0.078±0.050(a)	0.077±0.083(a)	0.085±0.057(a)	0.065±0.045(a)	0.012±0.013(a)	0.025±0.005(a)
	Megarhizo	0.204±0.060(a)	0.134±0.057(b)	0.149±0.076(a)	0.086±0.048(a)	0.086±0.103(a)	0.010±0.013(a)	0.016±0.110(a)
	Beyonik	0.149±0.039(a)	0.146±0.024(b)	0.106±0.034(a)	0.090±0.077(a)	0.083±0.062(a)	0.006±0.010(a)	0.019±0.009(a)
14	Control	0.140±0.084(a)	0.051±0.103(a)	0.127±0.089(a)	0.099±0.055(a)	0.050±0.057(a)	0.030±0.067(a)	0.051±0.092(a)
	Megarhizo	0.169±0.046(a)	0.160±0.060(b)	0.081±0.042(a)	0.077±0.052(a)	0.090±0.042(a)	0.006±0.010(a)	0.017±0.005(a)
	Beyonik	0.183±0.029(a)	0.097±0.043(ab)	0.096±0.055(a)	0.097±0.029(a)	0.077±0.034(a)	0.003±0.008(a)	0.014±0.005(a)
28	Control	0.257±0.076(a)	0.136±0.063(a)	0.131±0.058(a)	0.099±0.054(a)	0.047±0.048(a)	0.009±0.015(a)	0.026±0.011(a)
	Megarhizo	0.304±0.073(a)	0.164±0.100(a)	0.096±0.037(a)	0.159±0.100(a)	0.057±0.048(a)	0.009±0.015(a)	0.020±0.014(a)
	Beyonik	0.251±0.075(a)	0.134±0.069(a)	0.163±0.083(a)	0.100±0.098(a)	0.094±0.081(a)	0.000±0.000(a)	0.024±0.011(a)

Values represents means ± SE. Different letters in the same parameter data indicate significant differences by DUNCAN test (p≤0.05)

TABLE IX
GROWTH RATE (MM/MONTH) OF TRUNK DIAMETER BASED ON BIO-FERTILIZER AND ACCESSION NUMBER

Treatment	Accession No.								Average	Rank
	1	2	5	10	13	14	28			
Control	0.112	0.09	0.092	0.117	0.089	0.09	0.122	0.102	3	
Megarhizo	0.096	0.111	0.101	0.118	0.116	0.098	0.15	0.113	1	
Beyonic	0.1	0.115	0.115	0.12	0.098	0.095	0.134	0.111	2	
Average	0.103	0.105	0.103	0.119	0.101	0.094	0.135			
Rank	5	3	4	2	6	7	1			