International Journal of Thesis Projects and Dissertations (IJTPD)
Vol. 4, Issue 1, pp: (71-77), Month: January - March 2016, Available at: www.researchpublish.com

Early Growth of Arabica Coffee (*Coffea Arabica)* Seedlings Grown in Polyethylene Bags and Different Ratio of Potting Media

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Abstract: **The study aimed to evaluate the effect of polyethylene bags sizes, ratio of potting media and their interaction on the early growth of Arabica coffee; determine which treatment combination would show better growth of Arabica coffee seedlings; and determine the profitability of Arabica coffee seedlings production using the treatments.**
The experiment was laid out in factorial experiment in Completely Randomized Design with two polyethylene bag sizes and six ratio of potting media as treatments. Three replication and 20 seedlings were utilized in every treatment in all replication.
Seedlings in the larger polyethylene bags exhibited performed better in terms of average number of leaves, average diameter, average height, average monthly diameter increment, average monthly height increment and average surface leaf area than those in the smaller polyethylene bags.
Seedlings grown in the 10 percent vermicast performed best in terms of number of leaves, diameter, height, diameter increment, and height increment while those grown in 40 percent vermicast performed best in leaf surface area.
For the interaction effects of polyethylene bag sizes and potting ratio, seedlings grown in larger polyethylene bags with 10 percent vermicast obtained the best in terms of average diameter, average height, average monthly diameter increment and average monthly height increment. With larger polyethylene bags and 10 percent, 40 percent and 50 percent vermicast obtained the best in terms of average number of leaves and seedlings grown in larger polyethylene bags with 40% vermicast obtained the best in terms of average surface leaf area.

Keywords: **vermicompost, Arabica coffee, potting media, number of leaves, height, diameter, leaf surface area.**

I. INTRODUCTION

Coffee plays a major role in the world economy. It is the second most popular drink in the world, coming second to water and it is the second most traded commodity, next to petroleum.

The uses of coffee have developed over the years, starting from a beverage to an ingredient for food, medicine, and cosmetics. Coffee beans have been processed into wine while ground coffee have been used for fertilizers, skin moisturizers, anti-odor agents, stain and grease remover, hair darkener and ant or flea repellent.

Although the Philippines is not included in the top five coffee producing countries, the Philippine coffee is acceptable in the world market. Philippine Cavite Robusta is better than the Indonesian Robusta and is used in the blends of most known American and German instant coffees. The Philippines' roast/ground and soluble/instant coffee has found markets abroad and continues to receive repeat orders.

The Philippines, Vietnam and Indonesia have similar average farm sizes, but certainly the Philippines needs to catch up in terms of production compared with its neighboring countries. To be at par with the production of these two Asian countries, the Philippines needs to increase its production area and yield.

The Philippines is among the few countries that produces the four varieties of commercially viable coffee. Robusta is grown in all the main coffee producing areas of the country; Arabica is grown in higher areas of Northern Luzon; while Excelsa and Liberica are mostly grown in Batangas and some parts of Mindanao.

In 2013, the Philippines produced 78,634 metric ton of dried coffee berries composed of 69 percent Robusta, 24 percent Arabica, and 7 percent Excelsa and Liberica. The 2013 production is 12 percent lower from the 2012 production of 88,943 metric ton. The decline in production is attributed to the decreased area planted to coffee because of the following reasons: the peace and order situation in Sulu where most of the Robusta coffee plantations are located; the excessive rains during the flowering stage which hampered the harvesting in coffee farms; the low-buying price of coffee in CARAGA Provinces; and the continuous neglect of coffee farms in Davao del Norte.

The Philippine coffee continues to adopt strategies that would take advantage of the increasing demands both in the international and domestic markets.

Coffee has existed for centuries in the Cordillera Administrative Region and has been part of the culture and lifestyle of the Cordillerans. Of all the coffee varieties, Arabica is the most popular and is regarded as the most promising coffee variety grown in the Cordillera highlands due to the high elevation of this mountainous region. Arabica is traditionally grown in backyards and when fully grown and properly cultivated can yield as much as 1.5 kg green bean per tree.

Among the provinces, Kalinga is the top coffee producer in 2013 and accounts for 68 percent of the region's production. However, in terms of specific coffee variety, Benguet is the top producer of Arabica coffee as it accounts for 75 percent of the total Arabica production of CAR (548.34 mt) in 2013.

Considering the vast potential area for Arabica coffee production in the province, it is necessary to start producing quality planting materials using vermicast and packed in convenient sizes. The utilization of vermicast will positively contribute to the growth performance of coffee (Khaple, 2012); the same is the finding of Atik and Yilmaz (2014) for pine trees. Hence, this study is conducted to look into the potential of producing Arabica coffee through the use of vermicast at the same time growing it in most appropriate size of potting. The production of quality seedlings of coffee would also support coffee growers in Kalinga since coffee is its registered OTOP-Philippines commodity (DTI Philippines).

Objectives of the study:

Generally, the study aims to determine the effect of polyethylene bag sizes and ratio of potting media with emphasis on the utilization of vermicast in the early growth of Arabica coffee seedlings.

Specifically the study aims to:

1. evaluate the effect of polyethylene bags sizes, ratio of potting media and their interaction on the average number of leaves, average height, average diameter, average monthly diameter increment, average monthly height increment and average leaf surface area;
2. determine the best treatment combination to attain better growth of Arabica coffee seedlings; and
3. Determine the profitability of Arabica coffee seedlings production using the treatments.

II. METHODOLOGY

Soil preparation:

The components of the potting media are the top soil, carbonized rice hull and KASC organic fertilizer. Top soil was collected at the nearby area of the nursery. Clogs of soil was broken into fine tilth and sieved through a 2mm wire mesh. It was sterilized by sun drying. Carbonized rice hull and vermicast were taken from the production area of KASC organic fertilizer. Appropriate amount of top soil, CRH and vermicast was measured according to the treatment and mixed thoroughly. This prepared soil was potted into two sizes of polyethylene bag.

Seeds Source:

Arabica coffee seeds were procured from the Benguet State University through the KSU-Coffee Research and Development Center (CRDC). The seeds were sowed on October 2014. Seedlings emerged forty-five days after sowing.

Experimental Design, Treatments and Lay-out:

The experiment was set up as a 2 x 6 factorial design in Completely Randomized Design consisting of two sizes of polyethylene bags and six potting ratio. Three replication and twenty plants were utilized in the experiment for every treatment replication.

The treatments used in the study were as follows:

	Treatment Combination	
Treatment Number	Polyethylene Bags	Potting Ratio (Topsoil, CRH, Vermicast)
1	2"x2"x6"	50: 50: 0
2	2"x2"x6"	45: 45: 10
3	2"x2"x6"	40: 40: 20

4	2”x2”x6”	35: 35: 30
5	2”x2”x6”	30: 30: 40
6	2”x2”x6”	25: 25: 50
7	6”x8”	50: 50: 0
8	6”x8”	45: 45: 10
9	6”x8”	40: 40: 20
10	6”x8”	35: 35: 30
11	6”x8”	30: 30: 40
12	6”x8”	25: 25: 50

Nursery Management:

All seedlings were watered with equal amount. The potting bags were freed from weeds by pulling the growing grasses and other plants.

Growth Monitoring:

Sample plants were randomly selected and marked. From these plants the number of leaves, diameter and height were measured throughout the duration of the study. Measurement was conducted monthly after seedling were transplanted.

Measurement of Parameters at Harvest:

Final number of leaves, diameter, height and surface leaf area of the seedlings were measured at the termination of the study.

Average number of leaves: Leaves of the sample plants were counted, recorded and computed monthly.

Average height: Initial height was taken and the average monthly height until the termination of the study was computed. Height was measured from the brim of the polyethylene bags to the base of the apical bud.

Average diameter: Initial diameter was taken and average monthly diameter until the termination of the study was computed. Diameter was measured at the level of the brim of the polyethylene bags.

Average leaf surface area: Leaf surface of the sample plants was computed during the termination of the study. One full grown leaf was selected from every sample plants. Ten plants from each treatment were utilized. Leaf surface pattern was traced on a cross section paper and the area was computed.

Statistical Analysis:

All the data gathered were subjected to analysis of variance following the CRD Factorial computation. The Least Significant Difference (LSD) was employed to separate the treatment means.

III. RESULTS AND DISCUSSIONS

Observation:

The best time to transplant Arabica coffee seedlings in polyethylene bags are when a pair of leaves (butterfly like) has emerged. Seedlings grown in pure soil have lighter color in terms of leaves compared to seedlings grown with vermicast. It was observed that during heavy rains the height, diameter, number of leaves and also leaf surface area suddenly increased.

Results and Discussions:

TABLE 1. AVERAGE NUMBER OF LEAVES, DIAMETER, HEIGHT, MONTHLY DIAMETER INCREMENT AND MONTHLY HEIGHT INCREMENT OF ARABICA COFFEE SEEDLINGS GROWN IN TWO POLYETHYLENE BAG SIZES AND SIX RATIO OF POTTING MEDIA

Parameters	Treatments	Polyethylene bags		
	Ratio of potting media (topsoil, CRH, vermicast)	2”x2”x6”	6”x8”	Ratio of potting media (Mean)
Average Number of Leaves	50:50:0	10b	10b	10b
	45:45:10	10b	11a	11a
	40:40:20	10b	10b	10b
	35:35:30	10b	10b	10b
	30:30:40	10b	11a	11a
	25:25:50	10b	11a	11a
	Polyethylene bags (Mean)	10b	11a	11
Average Diameter	50:50:0	2.65e	2.75de	2.70c

(mm)	45:45:10	2.70e	3.21a	2.96a
	40:40:20	2.78cde	2.88bcd	2.83abc
	35:35:30	2.72e	2.99b	2.86ab
	30:30:40	2.72e	2.91bc	2.82abc
	25:25:50	2.74de	2.86bcd	2.80bc
	Polyethylene bags (Mean)	2.72b	2.93a	2.83
Average Height (cm)	50:50:0	18.03d	18.12d	18.08c
	45:45:10	19.22d	23.81a	21.52a
	40:40:20	19.95bc	19.76bc	19.86b
	35:35:30	19.52cd	21.35b	20.44ab
	30:30:40	19.56cd	21.03bc	20.30ab
	25:25:50	19.72c	19.83bc	19.78b
	Polyethylene bags (Mean)	19.33	20.65	19.99
Average Monthly Diameter Increment (mm)	50:50:0	0.20e	0.20e	0.20b
	45:45:10	0.21de	0.38a	0.29a
	40:40:20	0.24bcde	0.28b	0.26a
	35:35:30	0.22cde	0.29b	0.25ab
	30:30:40	0.22cde	0.27bc	0.25ab
	25:25:50	0.23cde	0.26bcd	0.25ab
	Polyethylene bags (Mean)	0.22b	0.28a	0.25
Average Monthly Height Increment (cm)	50:50:0	2.97d	2.97d	2.97b
	45:45:10	3.20d	4.35a	3.78a
	40:40:20	3.43cd	3.55bc	3.49a
	35:35:30	3.43cd	3.94ab	3.68a
	30:30:40	3.38cd	3.81bc	3.59a
	25:25:50	3.45bcd	3.36cd	3.41ab
	Polyethylene bags (Mean)	3.31	3.66	3.49
Average Leaf Surface Area (cm^2)	50:50:0	2.97d	2.97d	2.97b
	45:45:10	3.20d	4.35a	3.78a
	40:40:20	3.43cd	3.55bc	3.49a
	35:35:30	3.43cd	3.94ab	3.68a
	30:30:40	3.38cd	3.81bc	3.59a
	25:25:50	3.45bcd	3.36cd	3.41ab
	Polyethylene bags (Mean)	3.31	3.66	3.49

Note: Means of the same letter are not significantly different with each other (LSD)

Average number of leaves:

Table 1 presents the average number of leaves of Arabica coffee grown in two polyethylene bag sizes and six ratio of potting media. Average number of leaves differed significantly between sizes of polyethylene bag where the mean number of leaves of larger polyethylene bags were 11 was greater than those grown in polyethylene bags with 10. The average number of leaves increased significantly from three months of growing ($p<0.001329$). This result indicates the existence of a direct relationship between sizes of polyethylene bag and average number of leaves. This findings supported the earlier study conducted by Lay-asan (2012) which found out that larger potting bags have more number of leaves, larger diameter, taller seedlings and wider leaf surface area. Increased leaf production is also seen in treatments with higher amount of vermicompost. This finding is similar to that of Khaple (2012) where higher doses of organic manure resulted to greater leaf production.

Analysis of variance showed significant effects of ratio of potting media on the average number of leaves of Arabica coffee ($p<0.000001$). The seedlings grown under vermicast with 10 percent, 40 percent, 50 percent had average number of leaves of 11 followed by those grown under vermicast (pure soil, 20 percent, 30 percent) with average number of leaves of 10.

This result indicates unpredictable relationship between potting ratio and the number of leaves of Arabica coffee.

There were interactions between polyethylene bag sizes and ratio of potting media ($p<0.001329$) indicating changing effect of polyethylene bag sizes and ratio of potting media.

Average diameter:

Average diameter differed significantly between polyethylene bag sizes. Larger polyethylene bags gave larger average diameter of 2.93mm compared to smaller polyethylene bags with 2.72mm.

Analysis of variance showed significant effects on the ratio of potting media on the average diameter of Coffee arabica seedlings. The seedlings grown under vermicast (10 percent) had average diameter of 2.96mm followed by that of those grown under 30 percent (2.86mm) then that of those grown under 20 percent (2.83mm) then those grown under 40 percent (2.82mm) then those grown under 50 percent (2.80mm) and finally that of the seedlings grown in pure soil (2.70mm). This result indicates the existence of an inverse relationship between ratio of potting media and average diameter of seedlings.

The interactions between polyethylene bags sizes and ratio of potting media ($p<0.003$) indicated changing effects of polyethylene bags sizes and ratio of potting media on the average diameter of Arabica coffee seedlings. Largest average diameter was obtained from seedlings grown in large polyethylene bags in combination to 10 percent of vermicast; however, the addition of 20 percent gave similar effect. This only shows that the organic fertilization enhances plant growth (Salih Ati, Hadi, & Abdullah Abbas, 2013; & Berova, Karanadsidis, Sapundzhieva & Nikolova, 2013; Mulugate, 2014).

Average height:

Analysis of variance revealed that average height differed significantly between polyethylene bag sizes. Larger polyethylene bags gave taller seedlings of 20.65cm compared to polyethylene bags with an average height of 19.33cm.

Analysis of variance showed significant effects on the ratio of potting media on the average height of Arabica coffee seedlings. The seedlings grown under vermicast (10 percent) had average height of 21.52cm followed by that of those grown under 30 percent (20.44cm) then that of those grown under 40 percent (20.30cm) then those grown under 20 percent (19.86cm) then those grown under 50 percent (19.78cm) and finally that of the seedlings grown in pure soil (18.08cm). The average heights of the seedling were minimum in soil media without organic fertilizer, which could be due to absence of compost/organic matter and forest soil in soil substrate. The result is in line with Abebe (2000) and Husnia (1995) as cited by Mulugeta (2014), who reported that different soil mixtures affected the growth of shoot and root differently. This result indicates the existence of an inverse relationship between ratio of potting media and average height of Arabica coffee seedlings.

The interactions between polyethylene bag sizes and six ratio of potting media ($p<0.001$) indicated changing effects of polyethylene bag sizes and ratio of potting media on the average height of Arabica coffee seedlings. Tallest seedlings were grown from large polyethylene bags in combination to 10 percent of vermicast with 23.81cm.

Average monthly diameter increment:

Analysis of variance revealed that average monthly diameter increment differed significantly between polyethylene bag sizes. Larger polyethylene bags gave larger average monthly diameter increment in seedlings of 0.28mm/month compared to smaller polyethylene bags with 0.22mm/month.

Analysis of variance showed significant effects on the ratio of potting media on the average monthly diameter increment of Arabica coffee seedlings. The seedlings grown under vermicast (10 percent) had average monthly diameter increment of 0.29mm/month followed by that of those grown under 20 percent (0.26mm/month) then that of those grown under 30 percent, 40 percent, 50 percent (25.00mm) each and finally that of the seedlings grown in pure soil (0.20mm/month). This result indicates the existence of an inverse relationship between levels of vermicast and average monthly diameter increment of Arabica coffee seedlings.

The interactions between polyethylene bag sizes and ratio of potting media ($p<0.001$) indicated changing effects of polyethylene bag sizes and ratio of potting media on the average monthly diameter increment of Arabica coffee seedlings. The largest average monthly diameter increment was grown in large polyethylene bags in combination to 10 percent of vermicast of 0.38mm/month.

Average monthly height increment:

Average monthly height increment differed significantly between polyethylene bag sizes. Larger polyethylene bags gave larger average monthly height increment in seedlings of 3.66cm/month compared to smaller polyethylene bags with 3.31cm/month.

Analysis of variance showed significant effects on the ratio of potting media on the average monthly height increment of Arabica coffee seedlings. The seedlings grown under vermicast (10 percent) had average monthly height increment of 3.78cm/month followed by that of those grown under 30 percent (3.68cm/month) then that of those grown under 40 percent, 20 percent, 50 percent (3.59, 3.49, 3.41 respectively) and finally that of the seedlings grown in pure soil (2.97cm/month). This result indicates the no definite directional relationship between levels of vermicast and average monthly height increment of Arabica coffee seedlings.

There were interactions between polyethylene bag sizes and ratio of potting media ($p<0.001$) on the average monthly height increment of Arabica coffee seedlings. The largest average monthly height increment was grown from large polyethylene bag size in combination to 10 percent of vermicast with 4.35cm/month.

Average leaf surface area:

Analysis of variance revealed significant effect of polyethylene bag sizes. Larger polyethylene bags obtained larger surface area of 41.15cm^2 compared to 34.87cm^2 for smaller polyethylene bags. This result is synonymous to the findings of Poorter (2012) that on average, a doubling of the pot size increased biomass production by 43 percent. Further analysis of pot size effects on the underlying components of growth suggests that reduced growth in smaller pots is caused mainly by a reduction in photosynthesis per unit leaf area, rather than by changes in leaf morphology or biomass allocation. The appropriate pot size will logically depend on the size of the plants growing in them.

Significant differences on the average leaf surface area were found as affected by the ratio of potting media. It could be digested that 40 percent of vermicast gave the largest average leaf surface area of 39.34cm^2, followed by level 50 percent, 30 percent, 20 percent and 10 percent with 37.90, 36.14, 35.72 and 30.58 cm^2 respectively. It could be seen that the lowest average surface leaf area is obtained from seedlings grown in pure soil. This is synonymous to the findings of Edwards, et al. (2004) and Lazcano, et al., (2009) as cited by Atik and Yilmaz (2014).

Interaction effects revealed significant differences. It could be seen that seedlings grown in larger polyethylene bags and 20 percent of vermicast gave the largest average leaf surface area of 43.83cm^2.

Cost and Return Analysis:

Tables 2 & 3 show the cost and return analysis for 480 Arabica coffee seedlings production grown in two sizes of polyethylene bags and different ratio of potting media.

TABLE 2. COST AND RETURN ANALYSIS USING SMALLER POTS (2" X 2" X 6")

Particulars	T_1	T_2	T_3	T_4	T_5	T_6
Total cost (PhP)	1,838	1,889	1,940	1,991	2,042	2,093
Gross Income @ PhP15.00	7,200	7,200	7,200	7,200	7,200	7,200
Gross Income @ PhP20.00	9,600	9,600	9,600	9,600	9,600	9,600
Gross Income @ PhP25.00	12,000	12,000	12,000	12,000	12,000	12,000
Net Income @ PhP15.00	5,362	5,311	5,260	5,209	5,158	5,107
Net Income @ PhP20.00	7,762	7,711	7,660	7,609	7,558	7,507
Net Income @ PhP25.00	10,162	10,111	10,060	10,009	9,958	9,907
ROI (percent)@ PhP15.00	292	281	271	262	253	244
ROI (percent)@ PhP20.00	422	408	395	382	370	359
ROI (percent)@ PhP25.00	553	535	519	503	488	473

Table 2 showed that T_1 under small polyethylene had the highest return of investment with 292 percent, 422 percent and 553 percent with seedling prices PhP15.00, PhP20.00 and PhP25.00 respectively. This means that when you invest in seedling production using small polyethylene bags and without using organic compost you would earn at least three to five times your investment.

As shown on Table 3, the highest return of investment is when using a potting media without vermicast with 203, 303 and 404 percent at prices of seedlings PhP15, PhP20 and PhP25.

This would also show that seedling production is profitable using the bigger polyethylene bags and vermicast. And based on the result of the study 10 percent mixture of vermicast manifested the greatest result which means the addition of vermicast at 10 percent would produce better seedlings compared to using pure soil only. But most of the farmers prefer smaller potting bags.

TABLE 3. COST AND RETURN ANALYSIS USING LARGER POTS (6" X 8")

Particulars	T_1	T_2	T_3	T_4	T_5	T_6
Total cost (PhP)	2,380	2,482	2,584	2,686	2,788	2,890
Gross Income @ PhP15.00	7,200	7,200	7,200	7,200	7,200	7,200
Gross Income @ PhP20.00	9,600	9,600	9,600	9,600	9,600	9,600
Gross Income @ PhP25.00	12,000	12,000	12,000	12,000	12,000	12,000
Net Income @ PhP15.00	4,820	4,718	4,616	4,514	4,412	4,310
Net Income @ PhP20.00	7,220	7,118	7,016	6,914	6,812	6,710
Net Income @ PhP25.00	9,620	9,518	9,416	9,314	9,212	9,110
ROI (percent)@ PhP15.00	203	190	179	168	158	149
ROI (percent)@ PhP20.00	303	287	272	257	244	232
ROI (percent)@ PhP25.00	404	383	364	347	330	315

IV. CONCLUSIONS

Based from the results of the study, the following conclusions were drawn:

1. Larger polyethylene bags resulted to more number of leaves, larger diameter, taller seedlings, higher diameter increment, greater height increment and leaf surface area.

2. On the levels of vermicast 10 percent is best in terms of number of leaves, diameter, height, diameter increment, and height increment while 40 percent vermicast obtained the highest in terms of surface leaf area.

3. On the interaction effect, seedlings grown in larger polyethylene bags with 10 percent vermicast obtained the best in terms of diameter, height, diameter increment and height increment. With larger polyethylene bags and 10 percent, 40 percent and 50 percent vermicast obtained the best in terms of number of leaves while seedlings grown in larger polyethylene bags with 40 percent vermicast obtained the best in terms of surface leaf area.

4. The utilization of small polyethylene with no organic fertilizer generated the highest return of investment.

V. RECOMMENDATIONS

Based on the conclusions, the following are recommended:

1. Seedling production of Arabica coffee seedlings shall utilize specific larger polyethylene bags.
2. Ten percent of vermicast mixture of potting media is recommended.
3. Follow-up study on the performance of the seedlings in plantation is recommended.
4. BSF graduates with their technical capabilities may consider engaging themselves in seedling production.

ACKNOWLEDGEMENT

The authors would like to acknowledge Kalinga State University for providing us the necessary facilities for the conduct of this study.

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