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EFFICACY AND PROFITABLITY OF ORGANIC FERTILIZERS ON ARABICA COFFEE SEEDLING PRODUCTION

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ABSTRACT

This study was conducted to evaluate the efficacy of soil applied formulated organic solid fertilizers (FOSF) supplemented with sprayed formulated organic liquid fertilizers (FOLF) and to determine the cost and return on potted Arabica coffee seedlings under greenhouse conditions.

Results showed that a mixture of 100 g FOSF/pot having 1.7 kg soil and spray application of FOLF at a rate of 100 ml per 16 liters of water every 15 days is effective and economical in the production of vigorous Arabica coffee seedlings desired for planting.

Keywords: *organic fertilizer, Arabica coffee, seedling, FOSF, FOLF*

INTRODUCTION

Coffea arabica is a species of coffee indigenous to the mountains of Yemen in the Arabian Peninsula, hence, its name. It also originated from the Southwestern highlands of Ethiopia and Southeastern Sudan. It is also known as the "coffee shrub of Arabia", "mountain coffee" or "arabica coffee". *Coffea arabica* is believed to be the first species of coffee to be cultivated, being grown in southwest Arabia for over 1,000 years. It is said to produce better coffee than any other commercially cultivated species of coffee (Anonymous, 2009).

Arabica coffee production in the Philippines is mostly confined to the cool highlands in Benguet and Mountain Province in the Cordillera Region. To have sustainable production in these areas, appropriate soil and nutrient management technologies must be generated considering that the production areas are highly marginal lands with sloping and mountainous terrain.

In the Cordillera Administrative Region (CAR). The total land area planted to Arabica coffee is 629 hectares, broken down per province as follows: Benguet-256 hectare, Kalinga-184 hectares, Mountain Province-77 hectares, Ifugao-51 hectares, Apayao-40 hectares and Abra-21 hectares.

Organic agriculture is an ecological production management system that promotes and enhances biodiversity, biological cycles and soil biological activity. It is based on minimal use of off-farm inputs and management practices that restores, maintain and enhance ecological harmony (USDA, 2006). On the other hand, nutrient management is a system used by farmers to manage the amount, form, placement and timing of the application of nutrients. Its purpose is to supply plant nutrients for optimum forage and crop yields. It is also used to minimize nonpoint source pollution (runoff of pollutants to surface water) and contamination of groundwater and to maintain and/or improve soil condition (Brady, 2012).

Nutrient management program for coffee is imperative to attain profitable yield. Adequate and balanced supply of all essential nutrients is necessary to ensure good coffee stand and to improve yield, quality and benefit the environment. Most promising organic nutrient sources in coffee

production included cattle manure (Lekasi *et al.*, 2001; Chemura *et al.*, 2010; and Njoroge *et al.*, 1990) and coffee wastes like pulp and pruning utilized in combination with green manures and live mulch. These were effective in enhancing coffee growth and productivity and at the same time economically viable (Chemura *et al.*, 2010).

In order to have good quality Arabica coffee berries, there should be a healthy coffee tree which starts from healthy seedlings. Production of vigorous coffee plants at the nursery is the basis of their successful establishment in the field. Likewise, replacement of old Arabica coffee plantation requires high production of quality seedlings and knowledge of appropriate potting media for good seedling development (Marquez, 2010).

This study aimed to determine the efficacy of solid and liquid organic fertilizers formulated from locally available materials on the growth performance of Arabica coffee seedlings grown in pots with various levels of organic fertilizer and to determine the cost and return of using formulated organic fertilizers.

MATERIALS AND METHODS

Formulated organic solid fertilizer at different rates (FOSF) was mixed with soil in 3"x3"x10" pots where Arabica coffee seedlings were planted. Each pot contained 1.7 kilograms soil with (place kind/ pot size) FOSF in accordance with the treatments. The FOSF which had nitrogen, phosphorous and potassium (NPK) content of 1.79%, 1.61% and 3.10%, respectively was prepared by using composting technology using on-farm available raw materials such as coffee hull, *alnus* leaves and pig manure at the BSU-IHFSA farm. The farm is located at Bektey, Longlong, Puguis, La Trinidad, Benguet (N 160 26' 51.6", E 1200 33' 51.8") at 1,362 meters above sea level. On the other hand,the formulated organic liquid (FOLF) was prepared as compost tea using sunflower, calliandra and coffee pulp as substrates. It has an NPK content of 0.22%, 0.04% and 0.35%, respectively and sprayed at 100 ml/16 liter of water every 15 days to coffee seedlings to all treatments on supplementary fertilizer.

There were 10 sample coffee seedlings per treatment arranged in Completely Randomized Design (CRD) with 3 replications.

The treatments were:

Soil alone (untreated)
100g Formulated Organic Solid Fertilizer (FOSF)/pot
200g FOSF/pot
300g FOSF/pot
400g FOSF/pot
300g BSU Growers Compost/pot

The BSU Growers Compost has a nutrient content of 1.79%, 3.88% and 4.11% NPK respectively.

Data Gathered:

1. Seedling height. This was obtained by measuring from the root collar up to the shoot of the sprouts at two months and 12 months after transplanting.

2. Stem diameter. This was recorded by measuring the stem an inch from the base of the sprouts at two months and 12 months after transplanting (MAP).

3. Seedling Vigor. Seedling vigor was visually evaluated at two and 12 months after transplanting (MAP) using the following rating scale:

Rating	Description
5	Very vigorous
4	Vigorous
3	Moderately vigorous
2	Slightly vigorous
1	Weak

4. Root-Shoot Ratio. This was obtained by dividing the dry weight of roots and dry weight of shoots 12 months after potting.

$$\text{Root-Shoot Ratio} = \frac{\text{weight of roots}}{\text{weight of shoots}}$$

5. Nutrient Deficiencies. Visual signs of

nutrient deficiencies were monitored and documented throughout the study using a digital camera. The captured images of the suspected nutrient deficiencies were cross referenced from the descriptions of various literatures for proper identification.

RESULTS AND DISCUSSION

Seedling Height and Stem Diameter

Table 1 shows the plant height and stem diameter of potted Arabica coffee seedlings applied with formulated organic solid fertilizer. Initial data revealed no significant differences on plant height and stem diameter. Similarly, at 12 months after potting, no significant differences in plant height and stem diameter were observed, although the tallest plants with 40.63 cm was taken from Arabica coffee seedlings applied with 200g FOSF per pot. It also affected the largest stem diameter at 11.23 mm. This indicates that organic fertilizer could improve the growth of the seedlings. Studies on the potential of using organic materials as nutrient sources in coffee production identified recycling coffee wastes such as pulp and prunings as direct inputs, or in combination with green manures and live mulch in nutrient management are effective in promoting coffee growth and yield and also economically viable (Chemura *et al*., 2010).

There were significant differences observed in seedling vigor two months after potting. This was noted on seedlings applied with 300g/pot BSU Growers Compost, 400g FOSF/pot and 100g FOSF/ pot were more vigorous (Table 2). However, vigor differences were not significant at 12 months after potting. All treatments exhibited excellent vigor (vigorous to very vigorous). According to Abadilla (1982), crops applied with organic fertilizers have greater resistance to pest and diseases. The humic acids and growth substances are adsorbed into the plant tissues through the roots and they favor the formation of protein by influencing the synthesis of enzymes. These increase the vigor and insect resistance of the plants. Soils high in organic matter allow little or no soil-borne disease because of the oxygen ethylene cycle in soil. The sap of the plants with organic matter is more bactericidal than plant not fertilized with organic material. Not only does humus confer immunity to plant pest and diseases but it also improves the quality of the crop characteristics that has very definite commercial value.

Root-shoot ratio

Root-shoot ratio of potted Arabica coffee seedlings was significantly affected by the rates of FOSF applied (Table 2). Comparatively higher root-shoot ratio was observed in seedlings not applied at all and those applied with 100 and 400g FOSF/pot and 300g BSU Growers Compost/ pot. This implies that 100g up to 300g FOSF or 300g BSU Compost could be sufficient to produce desirable Arabica coffee seedlings. Harris (1992), stated that an increase in soil fertility is commonly associated with a reduction in root-shoot ratio which means that shoot growth increases more in weight than in root growth. A low root-shoot ratio is almost always in response to favorable growing conditions. Any factor which improves growing conditions, such as favorable weather, fertilization, irrigation, aeration or pest control, results in a reduced root-shoot ratio. An increase in the root-shoot ratio, on the other hand, would indicate that a plant was probably growing under less favorable conditions.

Sign of Nutrient Deficiency Symptoms

Visual signs of nutrient deficiencies specifically nitrogen, potassium and magnesium were observed in the potted Arabica coffee seedlings applied with formulated organic solid fertilizers (Figure 2). Four months after potting, nitrogen deficiency as exhibited by pale green to yellow green leaves were noted mostly from plants not applied with organic fertilizer (control). Potassium deficiency (initial yellowing on the leaf edges followed by development of dead spots) was seen on seedlings applied with 100g FOSF, 200g FOSF/pot and control seedlings. Likewise, magnesium deficiency (green leaf veins against light green to yellow green background) was observed from seedlings applied with 400g FOSF/pot and 300g BSU Grower's Compost/pot. Nevertheless, all the Arabica coffee treatment seedlings showed marked improvement after six months and maintained vigor up to 12 months.

Table 1.Plant height and stem diameter of organically grown Arabica coffee seedlings12 months after transplanting as affected by different rates of formulated organic solid fertilizer

Treatment	Height (cm)		Stem Diameter (cm)	
	2MAP	12 MAP	Initial Data	12 MAP
Untreated	13.45	33.30	2.13	0.683
100g FOSF/pot	14.53	37.17	2.18	0.802
200g FOSF/pot	13.38	40.63	2.17	1.123
300g FOSF/pot	13.32	38.15	2.12	0.770
400g FOSF/pot	14.08	39.70	2.15	0.754
300g BSU Grower's Compost/pot	14.00	37.03	2.05	0.716

Table 2.Vigor and root-shoot ratio of organically grown Arabica coffee seedlings as affected by different rates of formulated organic fertilizers.

Treatment	VIGOR1		Root-Shoot
	2 MAP	12 MAP	Ratio
Untreated	2.73d	4.07	0.71a
100g FOSF/pot	3.37abc	4.50	0.63ab
200g FOSF/pot	3.00bcd	4.80	0.48b
300g FOSF/pot	2.83cd	4.65	0.46b
400g FOSF/pot	3.57ab	4.72	0.76a
300g BSU Growers Compost/pot	3.63a	4.63	0.63ab

Within columns, means of the same letter are not significantly different at 5% level by DMRT 1Vigor scale: 1 (weak), 2(slightly vigorous), 3 (moderately vigorous), 4 (vigorous), 5 (very vigorous)

Figure 1. Arabica coffee seedlings applied with different rates of formulated organic solid fertilizers six (6) months after potting

Nutrient Deficiency	Symptom
nitrogen	 Leaves are pale green to yellow green. (Original) Pale green to yellow green leaves of seedlings not applied with organic fertilizer.
	 Initial yellowing on the leaf edges followed by development of dead spots. These wereobserved from coffee seedlings applied with 100g FOSF, 200g FOSF/pot and seed-lings not applied four months after potting.
magnesium	 Green leaf veins against light green to yellow green background. These were observed from seedlings applied with 400g FOSF/pot and 300g BSU Grower's Compost/pot four months after potting.

Figure 2. Nutrient deficiency symptoms of potted Arabica coffee seedlings applied with different rates of formulated organic fertilizers.

Cost and return analysis in the use of formulated organic fertilizers in the production of Arabica coffee seedlings

By using the formulated organic solid fertilizer (FOSF) in the potting media at a rate of 100g/pot, a one kilogram of quality Arabica coffee seeds could produce around 3,325 organically grown Arabica coffee seedlings. A total production cost was PhP44,031.97 or equivalent to PhP 13.24/ seedling. At a selling price of PhP 20.00/seedling, a net income of PhP 21,813 could be generated. Hence, return on investment (ROI) was realized at 50.19% (Table 4).

Table 4. Cost and return of using 100 g/pot formulated organic fertilizer in organic Arabica coffee seedling production.

Particulars	Unit	Unit Price (Php)	Total (Php)
Total production			
(Arabica coffee seedlings, pcs)	3,325		
Receipts			
Cash			
Total volume sold (pcs)	2,993	20.00	59,850.00
Noncash			
Given away (pcs)	200	20.00	4,000.00
Others (pcs)	100	20.00	1,995.00
Total Returns			65,845.00
Expenses			
Cash			
Materials			
Arabica coffee seeds (kg)	1	300.00	300.00
Seed bags, 3x3x10" (pcs)	3,500	0.70	2,450.00
Weighing scale (10kg cap.)	1	800.00	800.00
Carburandum (pcs)	1	120.00	120.00
Shovel (pcs)	1	395.00	395.00
Black net (roll)	1	4,500.00	4,500.00
Grub hoe (pcs)	1	85.00	85.00
Organic fertilizer , bags	21	391.86	8,229.06
Commercial organic fertilizer			
Total Materials			16,879.06
Labor		Man-days	
Seedbed preparation	1	268.00	268.00
Sowing and mulching	2	268.00	536.00
Potting media preparation	1	268.00	268.00
Pricking and potting	12	268.00	3, 216.00
Total Labor			4,288.00
Total Cash expenses			21,167.06
Noncash			
Family labor			5,000.00
Land Rent			10,000.00
Depreciation			1,687.91
Marketing Cost			5,985.00
Total Noncash Expenses			22,672.91
Total Expenses			43, 839.97
Returns Above Cash Cost			44,677.94
Returns Above Non-Cash Cost			43,172.09
Net Return			22,005.03
ROI (%)			50.19

Note: 1kg coffee seeds= 3,500 pcs, Germination %: 95%. Labor cost: CAR Agriculture sector, as of June, 2015 (DOLE).

CONCLUSIONS AND RECOMMENDATIONS

The results indicated that formulated organic solid fertilizer (FOSF) plus formulated organic liquid fertilizer (FOLF) are able to supply nutrients needed for desired Arabica coffee seedling growth although no significant differences were noted for stem diameter and seedling height. The use of formulated organic solid fertilizer at a minimal rate of 100g/pot and spray application of 100 ml per 16 liters water of formulated organic liquid fertilize every 15 days interval effected vigorous seedling growth and comparatively high root-shoot ratio and is environmentally profitable at a return on investment (ROI) of 50.19%.

The demand for organically-produced Arabica coffee is steadily increasing. It is therefore recommended for Arabica coffee growers and other stakeholders to venture into organic production of Arabica coffee seedlings utilizing the aforementioned results of this study towards safe food production and environment.

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