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Seed germination and seedling performance of Cacao *(Theobroma cacao* L.*)* varieties using vermicompost based potting media

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Key words: Seed germination, Seedling performance, Cacao, Vermicompost, Potting media

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Abstract

The research was conducted to determine which among the seven varieties of cacao has a good germination and seedling performance using vermicompost based potting media. Specifically, it was conducted to determine the seed germination and seedling performance of the six varieties of cacao by germination percentage, survival rate, number of developed leaves, seedling height, length of roots, seedling vigor, pest and disease incidence. The research was laid out in Completely Randomized Design (CRD) with six treatments and three replications. The treatments were: T1 – BR25, T¬2 – K1, T3 – ICS40, T4 – UF18, T5 – K2, T6 – UIT1. The result showed that there was no significant effect of different cacao varieties using vermicompost as based potting media on the percentage germination at two weeks after sowing; four weeks afters sowing; number of developed leaves and survival rate. However, there were significant differences among the treatment in terms of percentage germination at three weeks after sowing; length of roots; seedling height; leaf area index and stem girth. Based on the result of the study, using the mixed 40% vermicompost, 30% alluvial soil ad 30% sand for cacao seedling propagation especially on K1 variety is recommended. It is further recommended that another trial must be conducted to give more conclusive result; another research and observations must be conducted using different soil media.

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Introduction

Cacao *(Theobroma cacao)*, is an evergreen tree in the family Malvaceae, grown for its seeds (beans) which are used primarily in the manufacture of chocolate. The cacao plant is a branching tree with simple, pointed (lanceolate) leaves which can measure up to 61cm (24 in) long and 10cm (4 in) wide.

Cacao is one of the major salable crop commodities grown in the Philippines. The climatic conditions and soil characteristics are conducive to growing cacao. The local and international demand for cacao product is way beyond the production capacity of the country and the world prices have been constantly favorable, making the local farmers to have an increasing interest for the said production. But how can we compete in world's supply of cacao products if the country's production in past years consistently decreasing? According to the Bureau of Agricultural Statistics (BAS), the country's production decreased from 128 metric tons (2001) to 73 metric tons (2012), the yield also decreased from 0.56mt/ha (2001) to 0.45mt/ha (2012) and the area to be harvested also decreased. The factors of the decreasing production and yield of cacao were: the cacao growers followed poor cultural management, lack of quality standard, lack information on pre- and- post harvest technologies and poor bean quality as it result to unhealthy seedlings.

The used of resistant variety of cacao is essential for production of the quality horticultural crops to improved. To ensure success in cacao farming, planting healthy plants must be done in a right place, time and consider also the variety that suits the soil condition to minimize the attacking of pest and diseases. The vigor of cacao seedling at the nursery can be influenced by varieties and the maturity of the bean at the time of sowing (Adenikinju 1969, 1972, 1974, 1975). Kinuha ko sa Onakoya study.

In order to grow seeds well, soil media is considered which plays important role for seed germination. (Wilson *et al.* 2001). Soil media specifically vermicompost is an environmental friendly substitute for peat in potting media with similar or beneficial effects on seedling performance and fruit quality. Vermicompost does not heat, can be used for improving soil texture and enhancing water-holding capacity of soil, it may be low in NPK but contains essential micronutrients (e.g., calcium, magnesium, manganese, copper, iron and zinc) not found in "complete fertilizers." Vermicompost has microbial activities that promote plant health and pest/disease resistance. This study was conducted to determine which among the six varieties of cacao has a good germination and seedling performance using vermicompost as based potting media. The study aimed to determine which among the six varieties of cacao has a good germination and seedling performance using vermicompost based potting media. Specifically, it aimed to determine the seed germination and seedling performance of the six (6) varieties of cacao in terms of the following parameters: (a) germination percentage, (b) number of developed leaves, (c) seedling height, **(**d) length of roots, (e) pest and disease incidence, (f) stem girth, (g) leaf area index and (h) survival rate.

Materials and methods

Experimental Design and Treatment

The experimental design used in the study was Completely Randomized Design (CRD) with six (6) treatments replicated three (3) times. The treatments were as follows: T_1 – BR25; T_2 – K; T_3- ICS40; T_4 – UF18; T_5 – K2; and T_6 – UIT1.

Cultural Maintenance and Operation

Propagation area

The cacao nursery of the Cagayan State University at Lal-lo was used for the propagation of the six cacao varieties to protect the cacao form intense sunlight.

Preparation of the Soil Medium

Three hundred sixty (360) polyethylene bags with a capacity of one kilogram mixed soil media were used for the study. Each treatment composed a 40% vermicompost, 30% sand, and 30% alluvial soil. The soil media were sterilized through sun drying.

Securing the Planting Materials

The varieties of cacao seeds (K1, K2, BR25, ICS40, UF18 and UIT1) were secured at Cruz's Cacao Farm.

Seed Preparation

Seeds were selected from ripe and healthy pods. Seeds that were uniform in size and bigger were selected and seeds that were swollen and of different shape were discarded. Mucilage that covers the seeds was removed by rubbing the seeds with sand and wash with water. The cleaned seeds were soaked in fungicide solution for ten (10) minutes to avoid the attacking of fungus. Seeds were spread in a wet sack covered with wet newspaper for twenty-four (24) hours. Seeds were sown not more than 1cm deep in the prepared polyethylene bags.

Watering Management

Watering was done using sprinkler to ensure that the soil were moist all the time to induce the propagation and development of roots. Watering was done as the need arises.

Weeding

Weeding was done by removing the weeds growing in the polyethylene bags. All weed growing along the spaces of polyethylene bags were likewise removed through hand weeding. This was done to avoid competition of nutrients needed by plants.

Gathered Data

Percentage Germination – this was taken by counting the germinated seeds at weekly interval 28 days after sowing. Using the formula:

$$Percentage\ Germination = \frac{number\ of seeds\ germinated}{number\ of seeds\ sown} X\ 100$$

Number of Developed Leaves – this was taken by counting the number of fully developed leaves per treatment.

Seedling Height – this was taken by measuring the height of cacao seedlings after 60 days from the soil surface to the tip of plant using foot rule and was measured in centimeter (cm).

Length of Root – this was taken by measuring the length of root using foot rule (cm).

Pest and Disease Incidence – this was taken by counting the number of seedlings affected by pest and disease.

Stem Girth – this was taken by measuring the diameter of the cacao seedling 60 days after sowing using a vernier calliper 2cm from the soil surface. (Onakoya 2011).

Leaf Area Index – this was taken by computing the product of the length and width of two leaves per plant in a treatment and was multiplied by the leaf area factor of cocoa (0.75) which was measured incm^2.

Survival Rate – this was taken by calculating the percentage survival of cacao. Using the formula:

$$Survival\ Rate = \frac{number\ of seedlings\ survived}{number\ of seed\ sown} X\ 100$$

Results

Twenty-four hours after spreading the cacao seed on a wet sack covered with wet paper, BR25 had 20% pigtail root of the total population.

Ten days after sowing (10WAS), one hundred percent (100%) of the sowed cacao seed in UIT1 had already germinated, Sixty-six percent (67%) in BR25 and K1, Fifty percent (50%) in treatment 5 and thirty-three per cent (33%) in ICS40 and UF18.

Thirty- two days after sowing (10WAS), K1 was observed to be the first treatment to produce new shoots, followed by UIT1 (33 days), K2, BR25 (34 days), ICS40 (38 days) and UF18 (40 days). Forty days after sowing (40WAS), it was observed that UF18 was the first to drop cotyledon with an average 35% followed by ICS40 (5%), BR25 and UIT1 (1.6%).

Germination Percentage

Two weeks after sowing (WAS), results showed that the six cacao varieties germinated at different rates. The highest percentage germination were obtained by BR25 and K1with a mean of 100% followed by K2 and UIT1, with a mean of 98.33%, ICS40, 95% and the lowest was UF18 with a mean of 93.33% (Table 1.). At 3 WAS, the germination rate were increased. BR25, K1, K2 and UIT1 had 100% germinated seeds while ICS40 had 95% and UF18 had 93.33% germinated seeds. Honest Significant Difference Test reveals

significant differences among treatments. BR25, K1, K2, UIT1 and ICS40 were not significantly different with each other, while BR25, K1, K2 and UIT1 were significantly different from UF18 and UF18 was not significantly different from ICS40 (Table 1). At four (4) WAS, the germination of the seeds were completed. BR25, K1, K2 and UIT1 had the highest germination rate of 100% while ICS40 and UF18 had 98.33% respectively (table1c). The differences among treatments were not significant (Fig. 1).

Number of Developed Leaves

Table 2 shows the number of developed leaves. Results revealed that the most number of developed leaves was obtained by K1, followed by K2, UIT1, BR25, ICS40 and UF18 with means of 6.67, 6.50, 5.89, 5.33, 5.11 and 4.11 respectively.

However, numerical differences among treatments on this parameter did not prove any significant result as gleaned in the Analysis of Variance in Appendix Table 2.

Seedling Height

Table 2 shows the height of cacao per variety. It showed that K1 was the tallest among the six varieties of cacao with a mean of 36.72cm followed by K2 with 36.19cm, UIT1 with 34.38cm, BR25 with 29.72cm, ICS40 with 29.54cm and UF18 was the smallest with a mean of 23.80cm.

Table 1. Percentage Germination and number of developed leaves of cacao -varieties 2, 3, 4, WAS) using vermicompost based potting media.

Treatments	Percentage Germination			Number of Developed Leaves
	2WAS	3WAS	4WAS	4WAS
T_1 – BR25	100	100a	100	5.33
T_2 – K1	100	100a	100	6.50
T_3–ICS40	95	95ab	98.33	5.11
T_4 – UF18	93.33	93.33b	98.33	4.11
T_5 – K2	98.33	100a	100	6.67
T_6 - UIT1	98.33	100a	100	5.89
	ns	*	ns	ns

ns - not significant

* - significant at 0.05 level

WAS- weeks after sowing

Honest Significant Difference Test showed that K1 was not significantly different from K2 and UIT1 but significantly different to BR25, ICS40 and UF18. However BR25 and ICS40 were not significantly different from each other but significantly different from UF18.

Length of Roots

Table 2 shows the result of the length of roots per variety. It shows that UIT1 had the longest length of roots with a mean of 21.59cm followed by BR25 with 20.62cm, K1 with 19.13cm, K2 with 18.02cm, UF18 with 17.33 and the shortest length was ICS40 with 1.51cm. The Tukey's Honest Significant Difference Test among treatments indicates that UIT1was significantly different to ICS40. However, length of roots in BR25 was not significantly different from K1, UF18, K2 and UIT1; BR25, K1, ICS40, UF18 and K2 do not also show any significant differences.

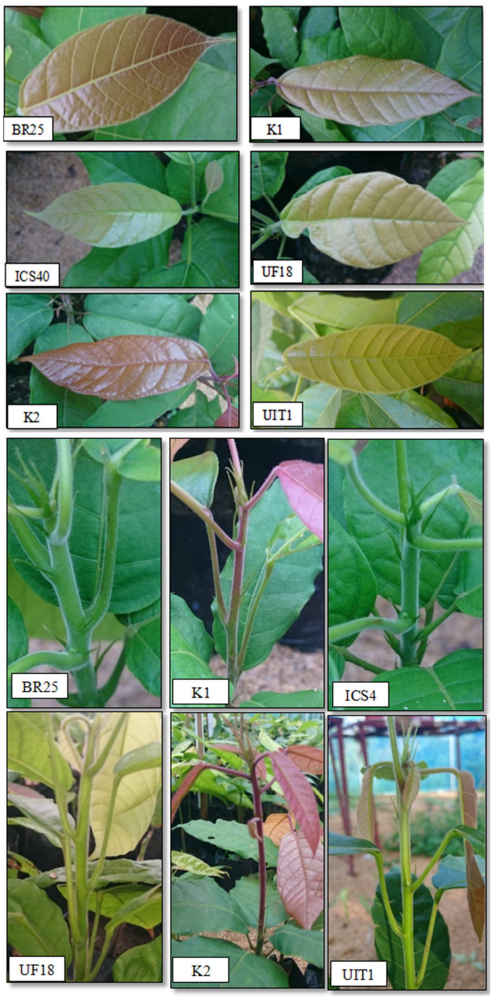

Fig. 1. Growth and vigor or cacao seedlings six varieties of cacao using vermicompost based potting media at CSU Lal- lo, Cagayan.

Stem Girth

Table 2 shows result of the stem girth of cacao varieties. It shows that K1 got the highest mean of 0.4567cm followed by K1, BR25, UIT1, ICS40 and UF18 with mean of 0.4467cm, 0.4133cm, 0.3867cm, 0.3367cm and 0.3000cm respectively. Honest Significant Difference Test revealed that BR25 was not significantly different from K1, K2 and UIT1; BR25 do not also show any significant differences ICS40 and UIT1; ICS40 was also not significant to UIT1. However, K1 and K2 were significantly different from ICS40 and UF18.

Leaf Area Index

Table 2 shows the result of leaf area index of cacao per variety. Results revealed that K2 obtained the highest mean with 31.90cm² followed by K1 (31.68cm²), UIT1 (27.32cm²), BR25 (24.11cm²), ICS40 (17.12cm²) and UF18 (16.84cm²). Analysis of variance reveals significant differences among treatments. The honest significant difference test among treatments indicates that BR25 was not significantly different from K1 and K2; BR25 was not significantly different from ICS40, UF18 and UIT. However, K1 and K2 were significantly different from ICS40 and UF18.

Table 2. Survival rate of six varieties of cacao using vermicompost based potting media at CSU Lal-lo, Cagayan.

Treatments	Seedling Height	Length of roots	Stem Girth	Leaf area index	Survival rate
	4WAS 3	4			
T_1 – BR25	29.72b	20.62ab	0.4133ab	24.11ab	100
T_2 – K1	36.72a	19.13ab	0.4567a	31.68a	100
T_3 – ICS40	29.54b	16.51b	0.3367bc	17.12b	98.33
T_4 – UF18	23.80c	17.33ab	0.3000c	16.84b	96.67
T_5 – K2	36.19a	18.02ab	0.4467a	31.90a	100
T_6 - UIT1	34.38a	21.59a	0.3867abc	27.32ab	100
	*	*			

ns - not significant

* - significant at 0.05 level

WAS- weeks after sowing

Survival Rate

Table 2 shows the result of survival rate of cacao varieties. Results revealed that the highest rate were obtained by BR25, K1, K2 and UIT1 with means of 100% followed by ICS40 and UF18 with means of 98.33 and 96.67, respectively. However, numerical differences among treatments on this parameter did not prove any significant result as gleaned in the Analysis of Variance (ANOVA).

Discussion

According to the study of Govindapillai Seenan Rekha, *et al.* (2018), 50% vermicompost treatment showed great potential to increase the performance, growth of chilly plant and improvement of soil quality. Chilly plants grown in vermicompost-amended soil showed enhanced growth rate when compared to plants treated with plant growth regulators (PGR). The study positively highlights the importance of organic farming; therefore, vermicompost may be put to good use as a natural fertilizer for cereals and vegetable crops for increased production and for sustainable agricultural systems.

Accordingly, vermicompost is a nourishing organic fertilizer having high amount of humus, nitrogen—2–3% phosphorous—1.55–2.25%, potassium—1.85–2.25%, micronutrients, more beneficial soil microbes like 'nitrogen-fixing bacteria' and mycorrhizal fungi. Vermicompost has been scientifically proved as miracle plant growth enhancer (Chaoui *et al.*, 2003; Guerrero 2010). Arkansan and Ismail (2012) reported that worm's vermicast contains 7.37% nitrogen and 19.58% phosphorous as P2O5. Microbial population of N2-fixing bacteria and actinomycetes increases by the application of vermicompost. The amplified microbial activities improve the availability of soil phosphorous and nitrogen. Vermicomposting is an aerobic, biological method and is proficient to convert eco-friendly humus like organic substances (Chanda *et al.*, 2011). Vermicompost stimulates to influence the microbial activity of soil, increases the availability of oxygen, maintains normal soil temperature, increases soil porosity and infiltration of water, improves nutrient content and increases growth, yield and quality of the plant (Arora *et al.*, 2011).

The same results are found in many organic fertilization studies on cacao seedlings and other fruit trees. In a trial on a marginal, acidic soil in South

Sulawesi, young PBC123 cocoa trees were supplied with compost, mineral fertiliser (NPK fertilizer and urea) or dolomite, alone and in combination. After 20 months, the trees supplied with compost were taller, flowered more profusely and had a five-fold higher dry bean yield than other treatments (S. Mulia, P. J. Mcmahon, A. Purwantara *et al.*, 2017).

According to S. Bokhtiar and K. Sakurai, (2005), in sugarcane, application of organic manure in combination with chemical fertilizer increased absorption of N, P and K in sugar cane leaf tissues both in the plant and ratoon crop as compared with chemical fertilizer alone. This led to higher cane and sugar yield of both crops, thus explained that organic carbon, total N, and available P, K & S contents of soils increased slightly due to incorporation of organic manure. It appeared that 25% reduction of fertilizer application is possible if FYM or press mud at 15 t ha^{-1} is used in plant and ratoon crops of sugarcane.

Conclusions

The result showed that there was no significant effect of different cacao varieties using vermicompost as based potting media on the percentage germination at two weeks after sowing; four weeks afters sowing; number of developed leaves and survival rate. However, there were significant differences among the treatment in terms of percentage germination at three weeks after sowing; length of roots; seedling height; leaf area index and stem girth. Based on the result of the study, using the mixed 40% vermicompost, 30% alluvial soil ad 30% sand for cacao seedling propagation especially on K1 variety is recommended. It is further recommended that another trial must be conducted to give more conclusive result; another research and observations must be conducted using different soil media.

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