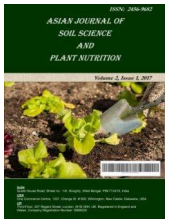

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Study on the Effectiveness of Natural Organic Fertilizers on Cassava (*Manihot esculenta* Crantz.*)* Cultivation

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Authors' contributions

This work was carried out in collaboration between both authors. Author PPM designed the study, wrote the protocol and managed the analyses of the study. Author KZL performed the statistical analysis and wrote the first draft of the manuscript. Both authors read and approved the final manuscript.

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ABSTRACT

Aims: In this study, the field experiment was performed to study the soil properties changes, tuber yield and nutritional quality of Cassava (*Manihot esculenta* Crantz.) using organic fertilizers.
Study Design: Two organic fertilizers treatments; Natural (wood ash 740 kg/ha + bat guano 740 kg/ha + defatted sesame meal 1880 kg/ha) and Vedagro (1480 kg/ha) along with Control (no fertilizer) were applied. The length of the experimental farm is 14 m, and the width is 7 m long. Totally seven rows of cassava cultivation were carried out in this 98 m^2 experimental farm. Fourteen ridges were prepared in each row. In the farm, one row of cassava cultivation (14 m long) including 14 ridges was treated with no fertilizer and assigned as "Control". Next three rows were treated with natural fertilizer (defatted sesame meal, bat guano, and wood ash) and denoted as 'Natural'. The other three rows were treated with commercial organic fertilizer Vedagro and it was assigned as 'Vedagro'.
Place and Duration of Study: The study area is located in Seik Kyi Village, Kyon Pyaw Township, Ayeyarwady Region (latitude 15º40'N and longitude 94º15'E), Myanmar. It was conducted during the

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2013 March and 2014 January cropping season.
Methodology: The soil samples were collected in randomized block design replicated three times. The characteristics and physicochemical properties of before fertilized and post harvest soil samples were studied by AOAC methods.
Results: Initial soils were acidic, very low in organic matter (OM), moderately low in N and P. The organic fertilizers used had relatively high N and P and good percentages of K, Ca and Mg. At the post harvest time, Natural and Vedagro increased soil OM, N, P, K and Mg significantly. Natural fertilizer did not much change soil pH, while Vedagro increased it. Proximate composition of Cassava on different treatments has been found as 57.02, 57.67 and 67.22% of moisture, 0.10, 0.08 and 0.09% of crude fat, 1.32, 0.56 and 0.76% of protein, 1.24, 1.01 and 1.12% of dietary fiber, 39.49, 39.77 and 38.56% of carbohydrate, 0.83, 0.91 and 0.85% ash, 161, 165 and 158 kcal /100 g based on fresh sample for Natural, Vedagro and Control, respectively.
Conclusion: Relative to Control, both Natural and Vedagro fertilizer increased tuber yield about 79%. The study revealed that both organic fertilizer treatments had high tuber yield, the high nutrient value in tuber and the least post harvest soil nutrients depleting.

Keywords: Bat guano; Cassava (Manihot esculenta Crantz*.); defatted sesame meal; nutritional quality; soil properties; tuber yield; wood ash.*

1. INTRODUCTION

The most influential factor in stabilizing soil fertility are the soil colloidal particles, clay and humus, which behave as repositories of nutrients and moisture and so act to buffer the variations of soil solution ions and moisture. The organic material of the soil has a powerful effect on its development, fertility, and available moisture. Following water and soil colloids, organic material is next in importance to soil's formation and fertility [1]. Of equal importance are the quantitative aspects of the soil as a habitat for plant roots. It is necessary that nutrients, air, and water are present in optimum concentrations for normal root development and plant growth. It is also necessary that enough of them be present throughout the growing season to meet plant needs. There are 20 essential chemical elements (plant nutrients) known to be required for normal vegetable growth. These elements can be supplied by either organic or commercial inorganic fertilizers [2].

Though many governments and agricultural departments go to great lengths to increase the supply of organic fertilizers, such as bulky organic manures and composting materials, there are just not enough of these fertilizers available to meet the existing and future fertilizer needs [3,4]. The slow and gradual release of organic fertilizer nutrients means that there is a reduced risk of nutrient burn from over-fertilization. This approach also means that fertilizer application is required less frequently, reducing operating cost and manual labor. With organic fertilizer, nutrient availability and uptake by plants occur at roughly an equal rate, meaning nutrients are preserved in soil and plant matter rather than leaching away with rainwater. The resulting plant growth occurs at a natural, healthy pace. This tends to produce stronger, more stable plants than those grown at an artificially accelerated rate, theoretically producing improved taste and nutritional value at the same time [5].

The fertilizers that used in this study are three natural organic fertilizers: defatted sesame meal, bat guano, wood ash and one commercial organic fertilizer, Vegadro. The residue sesame oilcake contains on an average 32% crude protein, 8-10% oil, total oil and albuminoids of 40-42% and rich in essential amino acids namely methionine and cystine [6]. Guano manure is an effective fertilizer and gunpowder ingredient due to its high levels of phosphorus and nitrogen [7]. Wood Ashes has been relegated to the home organic garden as an organic fertilizer. Wood ash contains between 4-10% potassium, 2% phosphorus, 25-50% calcium, 1-3% magnesium and trace amounts of sulphur. Vedagro also provides significant amount of the important nutrients for the plants development such as: amino acids, vitamins, and the minerals (Ca, Mg, S, etc) [8].

The fertilizer requirement for optimum yield in cassava is determined by the following factors, soil fertility status of the farmland, cropping system adopted and annual water rainfall [9]. Now grown throughout the tropical world, cassava is second only to the sweet potato as the most important starchy root crop of the

tropics. In Myanmar, cassava is widely grown in northern part of Ayeyarwady Region. Like all rapidly growing plants yielding carbohydrates, cassava has high nutrient requirements and exhausts the soil very rapidly. When cassava is grown on the land for a number of years in succession or in the rotation, the soil store of certain nutrients will be reduced and must, therefore, be returned to the soil by fertilization. Potassium salts favour the formation of starch, and nitrogen and phosphorus are essential for growth. However, if the soil contains large quantities of assimilated nitrogen, the result will be a heavy development of vegetative growth without a corresponding increase in root production [10]. The objective of the study was to determine the soil properties before and after fertilized soil and post-harvest soil in a cassava field, yield and nutritional quality of cassava over various treatments with organic fertilizer in compare with chemical fertilizer.

2. MATERIALS AND METHODS

2.1 Study Site

The study area is located in Seik Kyi Village, Kyon Pyaw Township, Ayeyarwady Region (latitude 15º40'N and longitude 94º15'E), Myanmar. It was conducted during the 2013 March and 2014 January cropping season. The mean annual rainfall is about 196 mm while the average temperature ranged between 24°C to 31°C in the prescribed zone (Fig. 1).

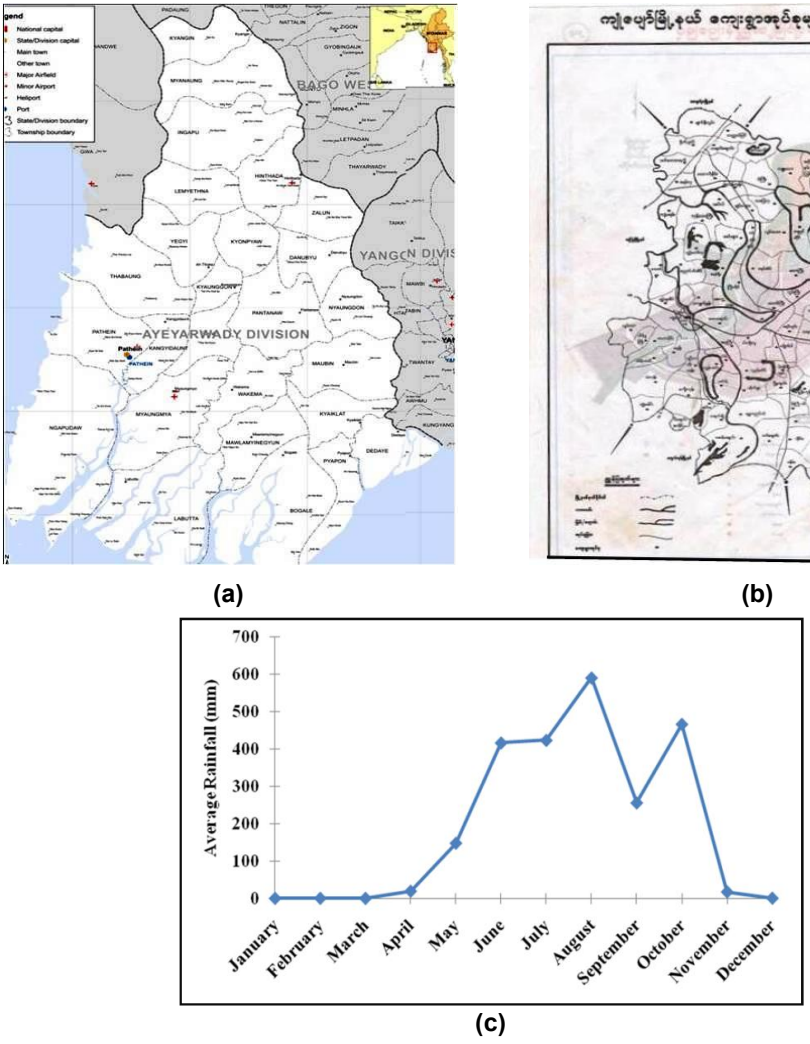


Fig. 1. Location map of the studied area

(a) map of Ayeyarwady Region, (b) map of Kyon Pyaw Township (c) Average Rainfall in Kyon Pyaw Township at 2013

2.2 Preparation of Fertilizers

Three organic fertilizers namely defatted sesame meal, bat guano, wood ash were collected naturally from Seik Kyi village, Kyon Pyaw Township, on September 2013. Commercial organic fertilizer, Vedagro fertilizer was collected from local market.

The sesame seed samples were cleaned manually by removing all the foreign matter such as stones, dirt and broken seeds. They were washed in abundant water before drained on a sieve. The traditional pressing method was used to extract the oil from sesame seed. The residue or defatted sesame meal was collected and dried at room temperature. This defatted sesame meal was soaked with water for about 3 or 4 days until to get decayed defatted sesame meal. The colonies of bat one dwelling in an abandoned tree in Seik Kyi village and this tree is nearby cassava plantations, paddy fields and small stretches of woodland. Droppings (guano) deposited beneath the roosting colony was collected for the plant growth study.

Wood ash has become plentiful around many home of Seik Kyi village which is collected from wood-burning stoves where uses mostly the branches or stems of Kokko, Mani-au-ga and Seik-chi trees which are locally distributed in this study area. Vedagro fertilizer was obtained from the market of Seik Kyi village, Kyon Pyaw Township. Commercial organic fertilizer "Vedagro" was produced from Vedan Vietnam Enterprise com., Ltd. The characteristics of four organic fertilizers were determined.

2.3 Soil sampling and Characterization

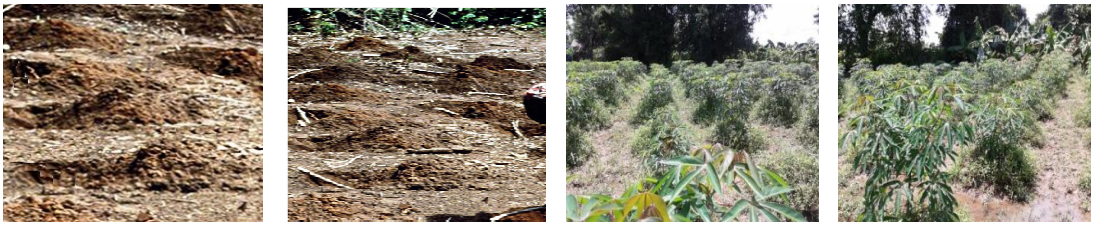
The soil samples were collected at the subsurface levels (10-15 cm) from the experimental farm of Seik Kyi village in randomly block design. The soil samples were air-dried and crushed using a wooden mortar and pestle and then sieved through a 2 mm mesh. The sieve samples were stored in polyethylene bags for analytical purposes. Soil organic carbon determination was done by AOAC method [11]. Texture determination was carried out by pipette method while soil pH was measured with glass-electrode pH meter on 1:2.5 soil: water solution mixture [12]. Total nitrogen was determined by macro Kjeldahl method. Available P (mg kg-1) was determined by AOAC method [11]. Ca, Na and Mg content were measured with atomic absorption spectrometry. Moisture content was determined by Oven dry method [13].

2.4 Experimental Design and Cassava Cultivation

The experimental design was a randomized complete block with three treatments. The length of the experimental farm is 14 m and the width is 7 m long. Totally seven rows of cassava cultivation was carried out in this 98 m^2 experimental farm. Fourteen ridges were prepared in each row. In the farm, one row of cassava cultivation (14 m long) including 14 ridges was treated with no fertilizer and assigned as “Control”. Next three rows were treated with natural fertilizer (defatted sesame meal, bat guano and wood ash) and denoted as ‘Natural’. The other three rows were treated with commercial organic fertilizer Vedagro and it was assigned as ‘Vedagro’.

The “Sein ta swe” (Local brand) type of cassava variety evaluated in this experiment were established in an open field in seven row as a completely randomized design (Fig. 2). The planting materials consisted of stem cutting of Cassava plant about 18 cm in length, containing between one and two nodes and planted in a vertical position along the top of the ridges. Cuttings are obtained from the stems of plants at least ten months old and 2.5 to 3.5 cm thick. After harvesting, these stems are stored in a dry place until the next planting. Cuttings from the upper part of the stem will grow faster, but their final yield is less. In general, tubers tend to originate from a great number of points and grow closer to the surface of the soil, making better use of fertilizers applied on the surface and also making harvesting easier.

On the age of 2nd week after planting, all types of cultivation were fertilized except “Control” treatment. For “Composite” treatment, three rows were applied by defatted sesame meal fertilizer (0.38 kg) was carried out around the base of the cuttings of each ridge. Then bat guano (0.15 kg) and wood ash (0.15 kg) organic fertilizing were performed on the 5th week after planting. Three weeks later, the plants were fertilized again by defatted sesame meal fertilizer (0.38 kg) and next three weeks later, bat guano (0.15 kg) and wood ash (0.15 kg) organic fertilizing were performed. For “Vedagro” treatment, three rows were firstly treated with vedagro fertilizer (0.15 kg) on the 2nd week after planting. Moreover, on the 5th, 8th, and 11th weeks, these plants were fertilized repeatedly by vedagro fertilizer (0.15 kg for each time). The characteristics of soil after fertilization were determined.



(a) (b) (c) (d)

Fig. 2. Cassava cultivation

(a) ridges of soil (b) soil with cassava stem cuttings (c) plants for "composite" treatment and (d) plants for "Vedagro" treatment

However in the case of "Control" treatment, there was no fertilizer was applied during the cultivation time. After fertilization, water was poured into each ridge every 3 or 4 days. On the 1st week of December, Cassava, highly perishable crop, starts to deteriorate and it would be ready to harvest. It would fall during relatively dry weather so that soil particles from the roots can easily removed. Because of the way of tubers grow, cassava is not a crop that ready to lend itself to mechanical harvesting. The tubers may spread over 1 m and penetrate the soil 50 to 60 cm deep. The growth and tuber yield parameters were determined from the experimental farm. The characteristics of soil after harvesting were determined.

After harvesting, the tuber from three different treatments; namely Natural, Vedagro and Control, were removed from the plants and washed the Cassava tubers, then, dried at room temperature. Some Cassava tubers which were applied by chemical fertilizer were also collected as a comparative sample. Among them, 0.5 kg of each fresh cassava tuber was used to determine the nutritional values: moisture, protein, fat, ash, carbohydrate, fiber and calorie content.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Characterization of Different Organic Fertilizers

According to these data, moisture content of vedagro was significantly less than other three fertilizers. Vedagro is commercial organic fertilizer pellet so that it was packing with plastic whereas other three natural fertilizers such as defatted sesame meal, bat guano and wood ash were not pellets and their moisture contents were relative high. The total nitrogen content in vedagro fertilizer was greater than other natural three fertilizers. The content of phosphorus in wood ash was greater than other three fertilizers. Because wood ash from different sources varies in the nutrients it contains and in its ability to neutralize soil acidity. The value of potassium in vedagro and wood ash are higher than the values for other two natural fertilizers. The high potential of ash was applied as a raw material resource for the production of acidic soil improvers.

The wood ash was rich in non-burned carbon which most probably is due of the content of non-burned wood particles and coals. The vedagro fertilizer has sweet flavor of molasses in addition it also has nutrient content much more than molasses for the reason that the fermentation created amino acids. The content of total Ca in wood ash is significantly greater than other three natural fertilizers. Due to the presence of calcium in comparatively large quantities, the ashes gave a strongly alkaline reaction which can neutralize acid soils. The value of wood ashes as a plant food depends mostly on the potassium content. The total Mg content in the defatted sesame meal and bat guano was not detectable. These results obtained showed that the total S content in defatted sesame meal is smaller than other three fertilizers because they are stable radical intermediate which prevent various food ingredients from oxidation. The organic matter content in vedagro was greater than three organic fertilizers because it has very rich organic matter with the highest nutrient contents in its class (Table 1).

3.2 Characterization of Soil Properties before Cultivation

The characteristics and physicochemical properties of before fertilized soil showed in Table 2. The type of soil is more suitable for cultivation because of possessing higher content of silt and the soil texture was assigned as silty

Table 1. Physicochemical property of various fertilizers

Test Parameter (%)	Fertilizers			
	Vedagro	Wood ash	Bat Guano	Defatted sesame meal
Moisture	2.954	45.724	43.87	57.731
Total N	10.608	0.386	1.609	1.379
Total P_2O_5	1.037	5.221	0.183	0.284
Total K_2O	5.13	4.608	0.422	0.343
Total Ca	3.847	13.08	0.769	1.539
Total Mg	0.093	1.867	-	-
Total S	2.508	0.664	0.65	0.051
Organic matter	38.781	1.737	0.709	11.067

clay. Soil pH values of soil were coincidence with the acceptable pH range to grow the most commercial crops because the best pH for growing plants is round 6.4. The representative soil that used in this study was the type of moderately acidic.

Table 2. Characteristics and physicochemical properties of before fertilized soil

Test parameter	Result
Texture	Silty clay
Sand (%)	2.10
Silt (%)	49.8
Clay (%)	47.0
pH	5.49
Moisture content (%)	2.24
Humus (%)	1.23
Organic matter content (%)	0.71
Ca (meq/100 g)	20.62
Mg (meq/100 g)	1.21
K (meq/100 g)	0.22
Total Nitrogen content (%)	0.17
Total phosphorus content (ppm)	10.1
Potassium content (mg/100 g)	10.44

As the moisture occupies the larger spaces in the soil which should be filled with air and plants are grow too well. The moisture content of soil sample was sufficient for cultivation of plant. 1.23% of humus and 0.71% of organic matter contents were found in the representative soil and it was designed as very low in organic matter content. The empirical data pointed out that high in Ca, medium in Mg and low in K. The concentration of calcium helps in membrane stability maintenance of chromosome structure and enzyme inhibitor. Magnesium helps the movement of sugar within plant. Sufficient amount of potassium increases the size of grains or seeds and improves the quality of fruits and vegetables. The deficient K causes the shriveled seeds or fruits. An abundance of nitrogen promotes rapid growth with a greater development of green leaves and stems. The presence of sufficient available phosphorus is required for seed formation and crops maturity.

3.3 Variation of Soil Properties in Cassava Cultivation

The soil samples were collected from experimental sites after fertilization the cassava plants at 10th July, 2013 and post harvesting at 6th December, 2013. From the results of after fertilization (Table 3), Natural treatment had relatively highest content of pH, humus, organic matter, exchangeable Ca, available K, total P and K compared with Vedagro and Control treatments. Soil application of Vedagro can also increase organic matter, exchangeable ions, available K and total NPK sufficiently. For post harvesting, among Natural, Vedagro and Control treatments, Vedagro gave the highest value of pH, moisture, Ca, Mg, and total NPK. Generally, soil NPK, exchangeable ion contents and pH increased in the order of Vedagro>Natural>Control. Treatment involving Natural fertilizer gave higher organic matter and humus. Moreover, increasing pH suggested vedagro treatment has the liming effect of basic exchangeable ions content.

The organic Natural fertilizer treatment increased pH, moisture content, N available potassium, available P and exchangeable K, Ca and Mg relative to the control treatment. The combined application of defatted sesame meal, bat guano and wood ash scored good result among all the treatments in terms of the content of exchangeable Mg, K, total nitrogen content, total phosphorus content and total potassium content. Organic Vedagro fertilizer treatment does not changed significantly in moisture, humus and organic matter contents of the soil for after fertilization and post harvesting. However, it was found to be increased nitrogen, available potassium, available P and exchangeable K, and Mg relative to the control treatment.

Table 3. Characterization of soil properties in cassava cultivation after fertilization and post harvesting

Test parameter	After fertilization			Post harvesting		
	Natural	Vedagro	Control	Natural	Vedagro	Control
pH	5.4	5.2	5.13	5.61	5.73	5.30
Moisture (%)	4.59	5.29	2.64	4.05	5.12	2.54
Humus (%)	1.55	1.39	1.17	1.54	1.35	1.27
Organic matter (%)	0.89	0.78	0.68	0.90	0.78	0.68
Ca (meq/100 g)	19.49	18.84	16.37	16.65	19.98	12.72
Mg (meq/100 g)	1.94	2.59	0.9	1.33	2.66	0.86
K (meq/100 g)	0.46	0.23	0.21	0.29	0.38	0.13
Total N (%)	0.22	0.37	0.17	0.21	0.31	0.11
Total P (ppm)	13.47	10.8	9.15	9.17	10.33	7.32
Total K (mg/100 g)	22.0	12.0	9.85	13.76	17.72	7.86

Analysis of the fertilizers used indicated it had considerable percentages of N, P, K, Ca and Mg; hence, nutrients released by the waste material should have contributed to improving nutrient availability to cassava on the infertile soils and invariably supported higher growth parameters. The application of Vedagro fertilizer scored best among all the treatments in terms of the content of exchangeable Mg, K, total nitrogen content, total phosphorus content and total potassium content. The results of soil physicochemical parameters was suggested that high and sustained NPK contents could be obtained with balanced NPK fertilizer combined with organic source of plant nutrients after cassava cultivation. Ojeniyi, et al. [9] also reported the considerable percentages of N, P, K, Ca and Mg of poultry manure contributed to improving nutrient availability to cassava on the infertile soils and invariably supported higher yield.

3.4 Nutrient Values of Fresh Cassava Tuber Obtained from Different Treatments

The nutritional values of fresh radish root from four treatments (Natural, Vedagro, Control) were observed in Table 4. From these data, the moisture contents were also found no significantly difference in all fresh cassava tubers from all treatments. The protein content was determined by AOAC method [11] and the data of protein contents were similar in cassava tuber from Vedagro and control. The fat content of cassava in Vedagro was smaller than of the other cassava tuber in Natural and control. From the data, the ash content of cassava tuber in Vedagro was found as the highest.

The content of carbohydrate from Vedagro was the highest because the contents of protein, fat, ash and fiber of cassava from Vedagro were smallest in compare with other two treatments. The fiber content of cassava tuber from Vedagro was smaller than other treatments. The calorie content of cassava tuber from Natural and Vedagro are the same and the result from Control was not much different with other treatments.

Relative to Control, the nutrient value in tubers of both organic fertilizer treatments is high. The energy value in cassava, growth and tuber yield parameters are also provided high results in Natural fertilizer treatment as well as commercial organic fertilizer, Vedagro treatment.

Table 4. Some nutritional values of fresh cassava tuber using various treatments

No.	Parameter	Content (%)		
		Natural	Vedagro	Control
1	Moisture	57.02	57.67	67.22
2	Protein	1.32	0.56	0.76
3	Fat	0.10	0.08	0.09
4	Ash	0.83	0.91	0.85
5	Carbohydrate	39.49	39.77	38.56
6	Fiber	1.24	1.01	1.12
7	Calorie Content (kcal/ 100 g)	161	165	158

3.5 Yield and Growth Parameters of Cassava Tuber after Harvesting

The cassava tuber yield and growth parameter were found to be statistically similar under Natural and commercial fertilizer treatments. The summary of these results were showed in Table 5. The range of tuber weight for treatment of Natural, Vedagro and control are such as 2.7-4.8, 3.6-7.4 and 1.7-3.5 kg per plant. In control treatment, the tuber weight was lighter than other natural, and commercial organic fertilizers treatments. The tuber length range in Vegadro was highest in compare with the other Natural and Control treatments. However, the tuber length in control was smallest than other two natural organic fertilizer treatments. Relative to Control, all fertilizer treatments increased about 2 times in tuber weight and 2 times and 1.5 times in tuber length for Natural and Vedagro fertilizers. All of the natural and commercial fertilizers were found to be effective in the growth of tuber weight in cassava cultivation. However, the longer the tuber length makes the weaker the tuber weight of the cassava.

The tuber girths of fresh cassava tuber which are obtained by using various fertilizers from experimental farm are shown in Table 5. The largest tuber girth was observed in organic fertilizer treatment and smallest tuber girth was observed in Control. Both organic fertilizer treatments were detected as almost 1.2 times higher than Control treatment in tuber girth. All of the application of natural fertilizers gave the growth performances of cassava tuber (Fig. 3).

3.6 Yield Percent of Cassava Tuber after Harvesting

The observed number of tuber which clustered from each plant and the yield percent of cassava tuber by using various fertilizers treatment are shown in Table 6. The number of tuber range in Natural, Vedagro and Control was found to be 9-11, 8-11 and 3-7 respectively. According to this data, the tubers of collected cassava in Natural treatment were found to be highest in compare with other three treatments. The tuber yield in field experiment were found as 11.1 t/ha of compost, 11.1 t/ha of vedagro and 6.2 t/ha of Control treatments. Relative to control, both Natural and Vedagro fertilizer increased tuber yield about 79%. Moreover, natural and commercial organic fertilizers were observed very efficient on the growth parameters and yield percent of cassava cultivation. These observations are coincident with earlier reported articles [14,15]. Eneji, et al. (1997) observed that farmyard manure with NPK fertilizer increased yield of cassava relative to manure or fertilizer alone. Whereas Okigbo (1989) also found that crop wastes such as those of legumes, rice and maize increased yield of cassava.

Table 5. Summary showing growth parameters of fresh cassava tuber

Used fertilizer	Tuber weight (kg/plant)		Tuber length(cm)		Tuber girth (cm)	
	range	Ave. ± SD	range	Ave. ± SD	range	Ave.± SD
Natural	2.7-4.8	4.5 ± 1.3^{b}	20-37	30 ± 5.6^{c}	15-21	17 ± 1.6^{b}
Vedagro	3.6-7.4	4.5 ± 1.3^{b}	19-35	23 ± 4.2^{ab}	17-20	17 ± 3.5^{a}
Control	1.7-3.5	2.5 ± 9.1^{a}	10-21	15 ± 1.3^{b}	10-18	15 ± 0.9^{b}

Ave. ± SD values bearing different superscript letters within columns are differed significantly (P < 0.05)

(a) **(b)** **(d)**

Fig. 3. Photograph of Radish root products by different fertilizers
compost fertilizer (b) vedagro fertilizer (c) control

Table 6. Summary showing yield parameters of fresh cassava tuber

Used fertilizer	No. of tuber	Tuber yield (t/ha)
Natural	10 ± 2.1^{a}	11.1 ± 3.2^{b}
Vedagro	10 ± 2.8^{a}	11.1 ± 2.5^{a}
Control	6 ± 2.3^{c}	6.2 ± 2.7^{b}

Ave. ± SD values bearing different superscript letters within columns are differed significantly (P < 0.05).

4. CONCLUSION

Analysis of the defatted sesame meal, bat guano, and wood ash indicated it had considerable percentages of N, P, K, Ca and Mg; hence, nutrients released by the waste material should have contributed to improving nutrient availability to cassava on the infertile soils and invariably supported higher growth parameters. This comparative study of the effects of commercial fertilizer, waste materials, and combined application could be applied on growth, yield parameters and nutrients composition of cassava in Delta Region of Myanmar. The organic Natural and Vedagro fertilizer treatment increased pH, moisture content, N, available potassium, available P and exchangeable K, Ca and Mg relative to the Control treatment. The application of organic fertilizers scored good result among all the treatments and suggested that high and sustained NPK contents could be obtained with balanced NPK fertilizer combined with an organic source of plant nutrients after cassava cultivation. The growth parameters of cassava are also provided high results in natural organic fertilizer treatment as well as commercial organic fertilizer, Vedagro treatment. The tuber weight, girth and tuber yield of the cassava was found in the order of Natural~Vedagro> Control treatments whereas the tuber length was also found in the order of Natural > Vedagro > Control treatments. However, the nutritional values and number of tuber in each plant in Natural and Vedagro are nearly the same. So, it can be concluded that these waste materials can be applied as cost-effective and beneficial fertilizers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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