J. Myanmar Acad. Arts Sci. 2023 **Vol. XXII. No.1**

NEEM LEAVES BASED ORGANIC FERTILIZER FOR CULTIVATION OF PEANUT CROP IN SOIL FROM YENANCHAUNG TOWNSHIP

Aye Aye Lwin[1], Kay Thi Moh Moh Win[2],Yin Yin Htun[3], Akayi Chan Nyein Oo[4],

Phyu Phyu Aye[5], Tin Oo Kyi[6]

Abstract

This research is concerned with the investigation of the preparation, and characterization of organic fertilizer from neem leaves, cow dung, and peanut shell. The raw materials were collected from the Yenanchaung Township. The organic fertilizers (OF) were prepared by three different weight ratios of neem leaves, cow dung, and peanut shell (100 kg: 100 kg: 100 kg) for OF-1, (125 kg:75 kg: 100 kg) for OF-2, and (150 kg:50 kg: 100 kg) for OF-3 respectively. The organic fertilizers were prepared by compost heap layer method. Field experiments were conducted in Kyawe-Pone Village, Yenanchaung Township, Magway Region to test the effect of organic fertilizer on the growth of peanuts with three treatments (T-1, T-2, and T-3) and a control. The highest yield of T-3 was 725.58 kg/ha, and the lowest yield of peanut in control was 543.49 kg/ha. In this work, the soil before cultivation and after harvesting was analyzed with regards to soil parameters. After harvesting nitrogen content, available phosphorus, and available potassium were higher in organic fertilizer-treated soil than before cultivation soil to maintain and sustain the soil fertility.

Keywords: organic fertilizer, neem leaves, cow dung, peanut shell, soil fertility

Introduction

Soil is essential to life, and it is a non-renewable, dynamic natural resource. Soil plays a vital role in sustaining life on the planet (Schoonover and Jackie, 2015). Soil texture influences nutrient retention, and has an important role in nutrient management. Soil organic matter is a primary source of carbon, which gives energy and nutrients to soil organisms (Bissonnais, 1996). The amount of organic matter depends not only on soil microorganisms, but also on the type of soil, vegetation, and environmental conditions such as moisture and temperature (Antil and Singh, 2007). Soil acidity, or alkalinity, can be measured by soil pH. It is an important indicator of soil health. It affects crop yields, crop suitability, plant nutrient availability, and soil microorganisms activity, which influence key soil processes (Dai *et al*., 1998). Plants require 16 essential elements. Carbon, hydrogen, and oxygen are derived from the atmosphere and soil water (Jones, 1998). Nitrogen is biologically combined with C, H, O, and S to create amino acids, which are the building blocks of proteins (Hungria and Vagas, 2000). Phosphorus aids in root development, flower initiation, and seed and fruit development (Hansch and Mendel, 2009). The primary function of phosphorus is the transfer of energy from plant leaves to their storage in sugars and starches (Epstein and Bloom, 2005). The presence of potassium is vital for plant growth because it is known to be an enzyme activator that promotes metabolism (Barber, 1995). Calcium is an activator of several enzyme systems in protein synthesis and carbohydrate transfer (Barker and Pilbeam, 2010). The essential micronutrients are zinc (Zn), iron (Fe), manganese

[1] Department of Chemistry, Yenanchaung University
[2] Department of Chemistry, Yenanchaung University
[3] Department of Chemistry, Yenanchaung University
[3] Department of Chemistry, Yenanchaung University
[4] Department of Chemistry, Yenanchaung University
[5] Department of Chemistry, Yenanchaung University
[6] Department of Chemistry, Yenanchaung University

(Mn), boron (B), chlorine (Cl), copper (Cu), molybdenum (Mo), cobalt (Co), vanadium (V), sodium (Na), and silicon (Si) (Chan and Ma, 2013).

Fertilizers are materials containing one or more nutrient elements in the form of chemical compounds of organic and inorganic nature (Bhatt *et al*., 2019). Organic fertilizers are natural materials from plant or animal sources, such as manure, green manures, crop residues, household waste, and compost, which directly and indirectly influence the properties of soil. Organic fertilizer increases root growth due to enhanced soil structure, promotes soil aggregates, and enhances cation exchange capacity (Bhatt *et al*., 2019). Raw materials such as crop residues, animal wastes, municipal wastes, and industrial wastes were applied as ~~a~~ fertilizing resources (Sawhney, 1976). Neem can grow in tropical and subtropical regions with semi-arid to humid climates. Neem leaves are cheap and useful fertilizers. Neem leaves improve the efficiency of fertilizer utilization in crop production through the gradual release of nitrogen to crops (Fathima, 2004). Cow dung is the most important source of bio-fertilizer but at the same time, cow's urine, cow's horn, and the dead body of a cow can be used for preparing effective bio-fertilizer (Hlaing, 2021). Peanut (*Arachis hypogaea* L.), or groundnut, is an annual herbaceous plant of the Fabaceae or Legume family.

Materials and Methods

Sample Collection

In this research, three raw materials of neem leaves, cow dung, and peanut shells were used for the preparation of organic fertilizer. Neem leaves, cow dung, and peanut shells were collected from the Industrial Zone in Yenanchaung Township, Magway Region.

Physicochemical Determination of Neem Leaves, Cow Dungs, Peanut Shells, and Prepared Organic Fertilizers

The pH of neem leaves, cow dung, peanut shells, and prepared organic fertilizers was determined by a pH meter. The moisture was determined by the oven-dry method. The total nitrogen content was determined by Kjedahal's method, the phosphorus content was determined by the same UV-visible spectrophotometric method, the potassium content was determined by the flame spectrophotometric technique, and the organic carbon and humus percent were determined by the titration method.

Determination of Some Elemental Compositions in Raw Materials and Prepared Organic Fertilizers

The elements present in raw samples (neem leaves, cow dung, and peanut shells) and prepared organic fertilizers were determined by the EDXRF technique at the Department of Chemistry, Monywa University.

Preparation of Organic Fertilizer from Neem leaves, Cow dung, and Peanut Shells

The three composted piles were prepared with plastic sheets, and the size of each pile was approximately 1.5 m in length, width, and height. The prepared organic fertilizers were made in three different ratios. The organic fertilizers (OF) were prepared by three different weight ratios of neem leaves, cow dung, and peanut shell (100 kg: 100 kg: 100 kg) for organic fertilizers-1(OF-1), (125 kg: 75 kg: 100 kg) for organic fertilizers-2 (OF-2), and (150 kg: 50 kg: 100 kg) for organic fertilizers-3 (OF-3) respectively. Organic fertilizers were prepared by the compost heap layer method. The temperature gradually rises and reaches its optimum within 7 days. The mixture maintained its optimum temperature for several days and then dropped gradually.

After three months, the compost-making material became black in colour. Then, organic fertilizers were obtained. Part of the fertilizer was kept in an airtight container and used for chemical analysis. Figure 1 shows a photograph of organic fertilizer piles.

Figure 1. Photograph of organic fertilizer piles

Application of Organic Fertilizers on Peanut Plants in Yenanchaung Township

A field experiment was carried out on sandy loam soil during (the rainy season) in 2022 at the farm, in Kyawe Pone village, Yenanchaung Township, Magway Region in Myanmar. The experiments were conducted in organic fertilizer-treated soil and control cultivation. The field experiments were carried out by the following.

Control	=	Untreated soil
Treatment 1 (T-1)	=	Soil treated with organic fertilizer-1 (OF-1)
Treatment 2 (T-2)	=	Soil treated with organic fertilizer-2 (OF-2)
Treatment 3 (T-3)	=	Soil treated with organic fertilizer-3 (OF-3)

Measurements of Plants

Plants measured were taken 15 days, 45 days, 75 days, and 120 days after cultivation. The plant height, plant width, number of leaves, number of flowers, and yield of components were measured for six randomly selected plants from each experiment.

Analysis of the Farm Soil Samples

Soil samples were collected from a farm in Yenanchaung Township, Magway Region. Soil samples were taken at a depth of about 20 cm from the surface in a zigzag manner, mixed thoroughly, and dried in the shade before sieving. Then the soil samples were stored in polythene bags and clearly labeled.

The soil samples were subjected to physical and chemical analyses using conventional and modern techniques. Some of this work was done in the laboratory of the Analysis Department of the Land Use and Seed Division, Ministry of Agriculture and Irrigation. The soil samples taken before cultivation and after harvesting were analyzed.

Results and Discussion

In this study, organic fertilizers were prepared from organic waste materials such as neem leaves, cow dung, and peanut shells. The effect of organic fertilizers on soil fertility was analyzed.

Sampling

In this research, three raw materials (neem leaves, cow dung, and peanut shells) were used in the preparation of organic fertilizer. The photographs of these samples are shown in Figure 2.

Neem leaves **Cow dung** **Peanut Shells**

Figure 2. Photographs of neem leaves, cow dung, and peanut shells

Physicochemical Properties of Neem Leaves, Cow Dung, and Peanut Shells

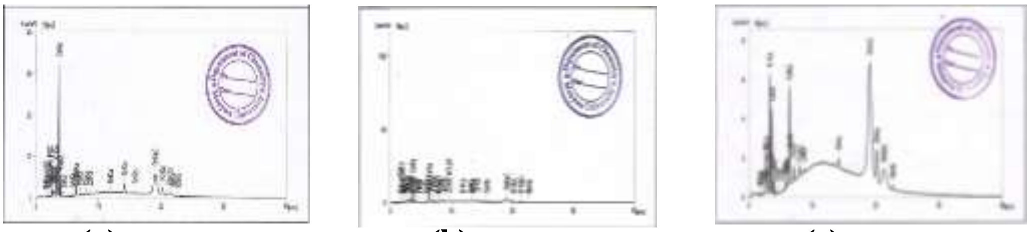
The pH values of neem leaves**,** cow dung, and peanut shells are 6.2, 7.5, and 6.5 respectively. The pH values of cow dung are higher than those of neem leaves and peanut shells. The pH values of all waste materials are found to be suitable for the preparation of organic fertilizer. The results are presented in Table 1, and Figure 2. Among the three samples, the cow dung sample found the least amount of moisture content, whereas the peanut shell samples showed the highest amount of moisture content. In the present work, it was found that the nitrogen contents of neem leaves, cow dung, and peanut shells were 3.118 %, 1.575 %, and 0.88 % respectively. The amounts of phosphorus in neem leaves, cow dung, and peanut shells were 0.379 %, 1.720 %, and 0.028 % respectively. The amounts of potassium in neem leaves, cow dung, and peanut shells were 1.162%, 0.422 %, and 0.29 %, respectively. It can be seen that the neem leaf sample contained the highest amount of nitrogen and potassium. The amount of phosphorous in cow dung was contained in all three samples. From these data, the waste materials contained the appropriate amounts of NPK needed for plants and soil fertility. So, these waste materials (neem leaves, cow *dung*, and peanut shells) were used for the preparation of organic fertilizers. Table 1 shows the results of some physicochemical properties of neem leaves, cow dung, and peanut shells.

Table 1. Physicochemical Properties of Neem Leaves, Cow Dung, and Peanut Shells

Sample	Parameters					
	pH	**Available N (%)**	**Available P (%)**	**Available K (%)**	**Organic Carbon (%)**	**C: N**
Neem leaves	6.2	3.118	0.379	1.162	53.9	44.1
Cow dungs	7.5	1.575	1.720	0.422	10.26	23.51
Peanut shells	6.5	0.88	0.028	0.29	55.8	63.41

Relative Abundance of Elements in Neem Leaves, Cow Dung, and Peanut Shells

The presence of elements (calcium, potassium, sulphur, iron, strontium, manganese, copper, titanium, and zinc in neem leaves, cow dungs, and peanut shells is shown by EDXRF spectra represented in Figures 3 (a), (b), and (c). It can be observed that the relevant elements (macronutrients and micronutrients) for plants were contained in neem leaves, cow dung, and peanut shell samples.



(a) **(b)** **(c)**

Figure 3. EDXRF spectra of (a) neem leaves, (b) cow dung, and (c) peanut shell

Preparation of Composted Organic Fertilizer

Temperature changes of compost pile during the composting process

In composting operations, temperature is a key parameter. The temperature profiles of three different ratios of composting organic fertilizers are shown in Figure 4. During the composting process, the temperature of three different compost piles was measured at (10 a.m, and 5 p.m) daily. The daily temperature of compost was recorded for up to 120 days. In the process, the temperature of the compost began at 41°C, and then the temperature was gradually increased to ~ 62°C after 30-31 days. The increase in temperature during the composting process is caused by the heat generated from the respiration and decomposition of sugar, starch, and protein by the population of microorganisms. The temperature pattern showed that there is a rapid process from the initial mesophilic phase to the thermophilic phase for this treatment. The temperature slightly decreased at 65-67 days because of the depletion of food sources,–overall microbial activity decreased, and the temperature fell to ambient (Cobb and Rosenfield, 1991). The highest temperature of 70°C was observed at 65-62 days, and the temperature dropped gradually again to reach 51°C at 86-90 days. The parameter for the temperature showed that the decomposition of organic matter occurs during the 90 days. After three months later, the compost was ready to use on the field. The photographs of prepared organic fertilizer are shown in Figure 5.

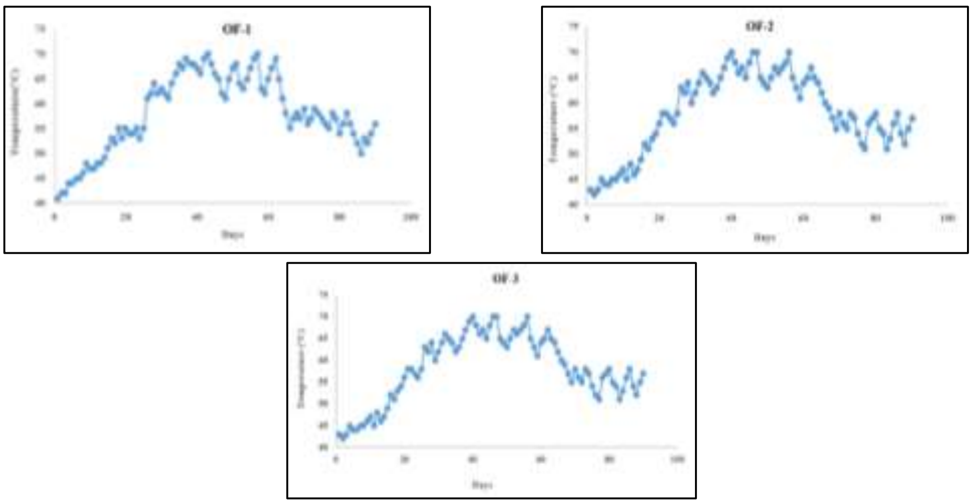


Figure 4. Temperature changes of organic fertilizers (OF-1, OF-2 and OF-3)

(a) OF-1 **(b) OF-2** **(c) OF-3**

Figure 5. Photographs of organic fertilizers (OF-1, OF-2 and OF-3)

Physicochemical Properties of Composted Organic Fertilizers

The pH, moisture content, organic carbon content, C/N ratio, total nitrogen content (N), phosphorus content (P_2O_5), and potassium content (K_2O) of organic fertilizers are specified. Therefore, chemical analyses were carried out by standard methods to know their specifications. The pH values of organic fertilizers were found to be in the range of 8.31-8.38.

The moisture content of organic fertilizers (OF-1, OF-2, and OF-3) was found to be 11.26 %, 22.41 %, and 18.79 % respectively. The organic carbon contents of OF-1, OF-2, and OF-3 were 18.01 %, 15.56 %, and 13.24 % respectively. In these results, the organic carbon contents were observed in the range of 13.24-18.01, and OF-1 had the highest organic matter content.

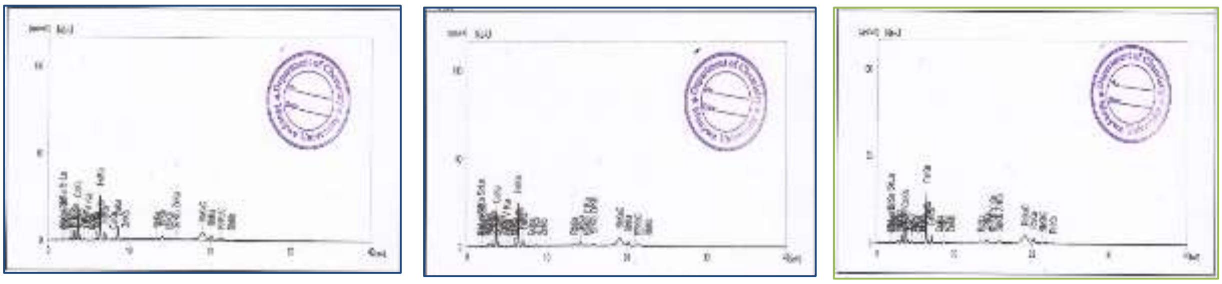
The C/N ratio of organic fertilizers was 17.83, 19.95, and 15.58. Although a C/N ratio of 10 to 20 normally indicates being in the range of mature enough, total organic matter plays a very important and sometimes spectacular role in the maintenance and improvement of soil properties. The results are reported in Table 2.

Table 2. Physicochemical Properties of Compost Organic Fertilizers

Fertilizers	pH	Moisture (%)	Organic carbon (%)	Total N (%)	Total P (%)	Total K (%)	C/N ratio
OF-1	8.38	11.26	18.01	1.01	0.145	1.06	17.83
OF-2	8.36	22.41	15.56	0.78	0.131	0.77	19.95
OF-3	8.31	18.79	13.24	0.85	0.096	0.53	15.58

Relative Abundance of Elements in Organic Fertilizers by EDXRF Method

The EDXRF spectra of prepared organic fertilizers are shown in Figures 6 (a), (b), and (c). The presence of silicon, calcium, potassium, iron, sulphur, titanium, manganese, zinc, strontium, copper, chromium, rubidium, zirconium, vanadium, and yttrium. It was observed that each spectrum indicated the presence of relevant elements for plant growth in organic fertilizers. The content of silicon, calcium, and potassium is higher than other elements in these organic fertilizers. These organic fertilizers have the highest content of silicon.



(a) OF-1 **(b) OF – 2** **(c) OF – 3**

Figure 6. EDXRF spectra of organic fertilizer (OF-1, OF-2, and OF-3)

Application of Organic Fertilizers by Cultivation of Peanuts

The field experiments were carried out on the farm at Kyawe Pone village, Yenanchaung Township, Magway Region Myanmar. From 23rd July, 2022, to 27th October, 2023, to study the effect of organic fertilizers on the growth of peanuts. The field was well prepared since good tillage is required for raising a good crop.

The size of each experimental plot design was (16 x 3) square feet for treatments. Each plot has one row. The row and plant spacing was 18 inches. Weeding and pest control were carried out whenever necessary. The use of fertilizers may affect, either directly or indirectly, the availability of soil nutrients. The application of fertilizer, particularly moisture, is one of the most important factors for the growth of plants.

Fertilizers observed in general stimulate early crop growth. Fertilizers may also have little effect on the rate of growth of certain crops, but at harvest, a decided increase in yield is noted (Rahman, 1991).

In this research, plant height, leaf length, number of seeds, and yield of peanut (*Arachis hypogaea* L.) were measured. The fieldwork did not only measure the rate of growth of peanuts, but also yield production. The results are shown in Figures 7 and 8, which show photographs of peanut plant growth on the farm.

(a) Control **(b) Soil treated with OF-1** **(c) Soil treated with OF-2** **(d) Soil treated with OF-3**

Figure 7. The photographs of peanut plant growth on the farm

(a)Feedings **(b)Treat**

Figure 8. Peanut plants grown on soil treated with organic fertilizers

Measurement of growth of peanut

From the time of cultivation to the harvested time, the time frame for peanuts is120 days. The growth factors of the peanut were evaluated in terms of the plant height (cm) and the number of peanuts. Plants were measured for eighteen randomly selected plants from the sample area. The sample plants were measured after 15 days of cultivation until maturity. The effect of organic fertilizer on plant height, plant width, and leaves of peanut is shown in Figure 9. Indicates a progressive increase in plant height with the age of the crop. The plant height of peanuts at (15, 45, 75, and 120) days after cultivation was recorded in treatments with organic fertilizers. The time frame was 120 days from the time of cultivation to the harvested time for peanuts. During this time frame, the growth and yield of peanuts are shown in Table 4. The growth characteristics of the peanut were analyzed in terms of the plant height (cm) and yield. The plant height was found to be 7.4 cm in control and T-1, 8.9 cm in T-2, and 9.9 cm in T-3 at 15 days. The plant height of peanuts increased with the increase in the growth period. After 120 days, the peanut plant height was found 43.18 cm in control and T-1, 45.72 cm in T-2, and 50.8cm in T-3. From these results, the highest plant was found to be in T-3. The plant height of control and T-1 was found to be shorter than the others.

Yield of peanuts

The yield of peanuts in T-3 was significantly higher than of control, T-1, and T-2. The highest yield of T-3 was 5.22 kg and the lowest yield of control was 3.91 kg in fresh weight on 100 plants. The highest yield of peanut in T-3 was 725.58 kg/ha, and the lowest yield of control and T-1 was 543.49 kg/ha. From these results, it was observed that the yield of peanuts applied with organic fertilizer was greater than that of these plants without the application of organic fertilizer. Thus, it can be reported that organic fertilizer can increase the growth and productivity of peanuts. Figure 10 shows the yield of peanuts.

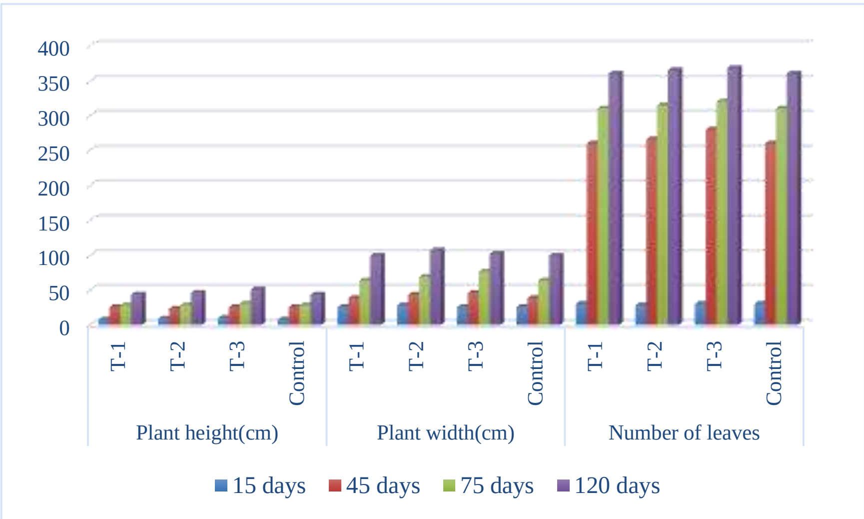


Figure 9. Plant height, plant width, and number of leaves of peanut plant on different days during cultivation

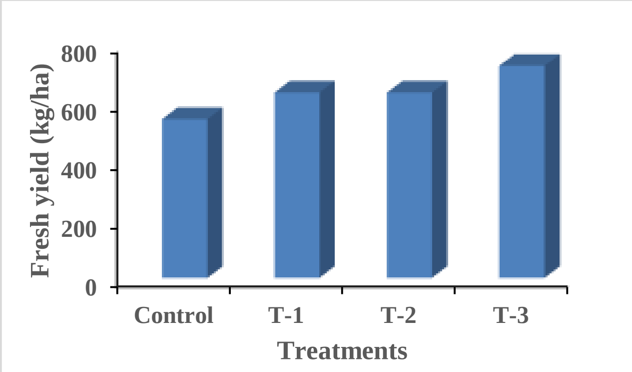


Figure 10. Yields of peanut plants

Analysis of the Farm Soil Before and After Cultivation

Soil is the most essential natural nutrient for vegetable and crop productivity. The fertility of soil can be assessed by the quality and stand of crop growth and yield. After cultivation of the plants, the texture, pH, electrical conductivity, organic matter, total N, available P_2O_5, available K_2O, exchangeable Ca^{2+}, exchangeable Mg^{2+}, exchangeable Na, and C/N ratio of soil treated with organic fertilizers (OF-1, OF-2, and OF-3) were investigated. The prepared organic fertilizers treated soils were compared with the control soil and the before cultivation soil.

The farm soil samples 1 (control), T-1 (soil treated with OF-1), T-2 (soil sample treated with OF-2), and T-3 (soil sample treated with OF-3) were composed of sand (83.90 %, 83.92 %, 84.64 %, and 84.13 %), silt (7.02 %, 6.89 %, 7.10 %, and 6.01 %) and clay (9.08 %, 9.19 %, 8.26 %, and 9.86 %) respectively. These farm soils were classified as loamy sand soil. According to the results, OF-2 treated soil (T-2) has the highest sand percentage 84.64 %. The clay content of T-3 was higher than that of soil samples T-1 and T-2, and the silt content of T-2 was higher than that of T-1, T-3, and other soil samples. The increase in sand content and decrease inslit content are indicative of the translocation of the three phases of sand, silt, and clay which may have taken place. It includes the mineralization of silt accompanied by aggregation into the sand phase (Orellana *et al.,* 1990).

The pH of these soils is slightly alkaline. The pH values of the soil samples before and after cultivation (control, T-1, T-2, and T-3) are 8.05, 8.01, 8.38, 8.36, and 8.3, respectively. Alkaline soil has a pH of 7.5 to 8.5, and acidic soil has a pH of 4.0 to 6.5. Several essential elements tend to become less available as the pH is raised from 5 to 7.4 or 8.0. At pH values below about 5, aluminum, iron, and manganese are often soluble in sufficient quantities to be toxic to the growth of some plants. The pH of the soil affects the root system and its capacity to absorb other nutrients (Srikanth, 1997).

The values of electrical conductivity of soil samples before and after cultivation (control, T-1, T-2, and T-3) were 0.07, 0.06, 0.05, 0.06, and 0.05 dS/m. The electrical conductivity of soil samples is similar in all three samples. The electrical conductivity is the most important measure of soil salinity and is indicative of the ability of the aqueous solution to carry an electric current.

The organic matter of soil samples before and after cultivation (control, T-1, T-2, and T-3) was 0.54, 0.42 %, 0.59 %, 0.78 %, and 0.62 %. Soil sample T-2 had the highest organic matter content. It releases nutrients for plant growth, promotes the structure, biological, and physical health of the soil, and is a buffer against harmful substances (Reijneveld, 2013).

The nitrogen content of soil samples before and after cultivation (control, T-1, T-2, and T-3) was 36, 51, 53, 55, and 56 % for each sample. The available phosphorous content of soil samples before and after cultivation (control, T-1, T-2, and T-3) was 1.72, 1.40, 1.70, 1.71, and 1.82 mg/kg, respectively. The content of soil sample T-3 was higher than control, T-1, and T-2. The available potassium content of soil samples (control, T-1, T-2, and T-3) were 78.66, 88, 109.9, 99, and 97 mg/kg. The available potassium content of soil sample T-1 was highest in these soil samples and the lowest was before the cultivation soil sample. The organic carbon content, pH, electrical conductivity, and exchangeable cations of control, T-1, T-2, and T-3 soils were permanently slightly changed under cultivation because most of them were removed from the soil by the crop produced. After harvesting, nitrogen content, available phosphorus, and available potassium were observed to be higher in organic fertilizer-treated soil than before cultivation soil to maintain and sustain soil fertility. The exchangeable Ca^{2+}, Mg^{2+}, and Na amounts were found to be lower before the cultivation of peanuts. The results of Ca^{2+} contents before cultivation and after cultivation (control, T-1, T-2, and T-3) were 10.3, 9.50, 13.21, 11.72, and 11.83 Cmol/kg, respectively. The amounts of Mg^{2+} contents were 3.95, 2.55, 2.86, 2.59, and 2.83 Cmol/kg. The exchangeable amounts of Na were 0.20, 0.12, 0.13, 0.15, and 0.16, respectively. According to these data, it was found that applying organic fertilizers can improve soil fertility and crop production.

Conclusion

This research is concerned with the investigation of the preparation, and characterization of organic fertilizer from neem leaves, cow dung, and peanut shell. The physicochemical properties of pH in neem leaves, cow dung, and peanut shells were (6.2, 7.5, and 6.5). According to these data, the raw materials were used as the main ingredients for the preparation of organic fertilizer. The organic fertilizers (OF) were prepared by three different weight ratios of neem leaves, cow dung, and peanut shell (100 kg: 100 kg: 100 kg) for OF-1, (125 kg: 75 kg: 100 kg) for OF-2, and (150 kg: 50 kg: 100 kg) for OF-3 respectively. pH values of organic fertilizer were observed to be slightly alkaline. Field experiments conducted to test the effect of organic fertilizer on the growth of peanuts with four treatments: control, T-1 (soil treated with OF-1), T-2 (soil treated with OF-2), and T-3 (soil treated with OF-3). The yield percent of peanuts in T-3 had significantly higher values than those of control, T-1, and T-2. The highest yield of T-3 was 725.58 kg/ha, and the lowest yield of peanut in control was 543.49 kg/ha. The result of this work showed that organic fertilizer increases the growth and productivity of peanuts. The soil parameters viz the organic carbon content, pH, electrical conductivity, and exchangeable cations of control, T-1, T-2, and T-3 soil showed slight changes under the cultivation of peanuts. After harvesting, nitrogen content, available phosphorus, and available potassium were higher in organic fertilizer-treated soil than on the soil untreated. The application of organic fertilizer is one of the local needs of farmer, cultivating cash crop. This research shows some contributions to the theme of rural area development.

Acknowledgements

We would like to express our heartfelt thanks to Dr. Cho Cho Myint, Rector, Yenanchaung University for her encouragement to do this research. We are also thankful to our research group for their effort. We are also thankful to the Department of Higher Education for the necessary supplement.

References

Antil, R. S. and M. Singh. (2007). "Effects of Organic Manures and Fertilizers on Organic Matter and Nutrients Status of the Soil". *Archives of Agronomy and Soil Science*, vol. 53, pp.519-528.

Barber, S. A. (1995). *Soil Nutrient Bioavailability. A Mechanistic Approach.* New York*:* 2nd Ed., Wiley

Barker, A.V. and D. J. Pilbeam. (2010). *Handbook of Plant Nutrition.* Boca Raton, FL: CRC Press

Bhatt, M. K., R. Labanya and H. C. Joshi. (2019). "Influence of Long-term Chemical Fertilizers and Organic Manures on Soil Fertility - A Review". *Universal Journal of Agricultural Research*. vol. 7(5), pp.177-188.

Bissonnais, Y. (1996). "Aggregate Stability and Assessment of Soil Crustability and Erodibility. Theory and Methodology". *J. Soil Sci.* vol. 47, pp.425–437.

Chen, Z. C. and J. F. Ma. (2013). "Magnesium Transporters and their Role in Al Tolerance in Plants". *Plant Soil*, vol. 368, pp.51-56.

Cobb, K. and J. Rosenfield. (1991). *Municipal Compost Management*. Cornell University Waste Management Institute

Dai, Z., Y. Liu., X, Wang and D, Zhao. (1998). "Changes in pH, CEC and Exchangeable Acidity of Some Forest Soils in Southern China during the Last 32-35 years". *Water Air Soil Pollut*., vol. 108, pp.377-390.

Epstein, E. and A. J. Bloom. (2005). *Minerals Nutrition of Plants: Principles and Perspectives*. Second Edition. Sunderland, MA: Sinauer Associates

Fathima, S. K. (2004). *Investigations on the Biology and Management of Phomopsis Azadirachtae on Neem*. Mysore, India: Ph.D. thesis, University of Mysore

Hansch, R. and R. R. Mendel. (2009). "Physiological Functions of Mineral Micronutrients (Cu, Zn, Mn, Fe, Ni, Mo, B, Cl)". *Curr. Opin. Plant Biol*, vol. 12, pp.259-266.

Hlaing, T. T. (2021). *Preparation of Organic Fertilizer from Banana Leaf with Cow Dung for Cultivation of Chilli (Capsicum annuum L.)*. Maubin: MSc Thesis, Department of Chemistry, Maubin University.

Hungria, M. and M. A. T. Vargas. (2000). "Environmental Factors Affecting N_2 Fixation in Grain Legumes in the Tropics, with an Emphasis on Brazil". *Field Crops Research*, vol. 65, pp.151-164.

Jones, Jr. (1998). *Plant Nutrition Manual*. Boca Raton, Fl: CRC Press. p.149.

Orellana, M., R. G. Barber and O. Diaz. (1990). "Effects of Deep Tillage and Fertilization on the Population, Growth, and Yield of Soya During an Exceptionally Wet Season on a Compacted Sandy Loam". *Research Soils and Tillage,* vol.17, pp.47-61.

Rahman, S. (1991). "Influence of Organic Matter on the Yield and Mineral Nutrition of Modern Rice and Soil Properties". *Bangladesh: Bangladesh Rice Journal*, vol. 2, pp.107-112

Reijneveld, J. A. (2013). *Unraveling Changes in Soil Fertility of Agricultural Land in the Netherlands.* Wageningen: Wageningen University, pp.201-214

Sawhney, B. L. (1976). "Leaf Compost for Container-grown Plants". *Journal of Hortscience.* vol.11(1): pp.34-35

Schoonover, J. E. and F. Jackie. (2015). "An Introduction to Soil Concepts and the Role of Soils in Watershed Management". *Journal of Contemporary Water Research & Education.* vol.154: pp.21-47

Srikanth, K. 1997. *Enrichments of Compost and its Effect on Soil Properties and Crop Growth.* Bangalore: Ph.D Thesis, University of Agricultural Sciences