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The Effects of Organic and Inorganic Fertilizers on Rice Nutrients and Soil Properties in Taungoo University Campus

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Abstract: Agricultural systems are a major factor affecting human health. Soil is one of the important factors for successful cropping in agriculture. The objective of this research was to investigate the effects of control, organic and inorganic fertilizers on soil properties and rice nutrients at Taungoo University Farm. The experiment comprised three treatments *viz.*, control (without fertilizer), organic farming (organic manures including paddy and black gram straw, cow dung) and conventional farming (chemical fertilizers including N, P, K). Soil samples were collected before and after paddy cultivation and analyzed to study the changes in soil properties as influenced by organic farming. Increase in physicochemical properties (moisture, organic carbon, humus), nutrients (N, P, K) and decrease in Fe, Mg contents were noticed in the soil under organic farming when compared to conventional and control farming after paddy cultivation. The nutritional values of the collected rice samples from organic, conventional and control farming such as moisture, ash, fat, fiber and protein were determined by AOAC methods. Mineral contents of rice samples such as K, Na, Ca, Mg and Fe were determined by atomic absorption spectrophotometer. A substantial increase in protein, fiber and decrease in fat were observed in the rice under organic farming. In the above context, it was observed that organic fertilizer caused better quality, safety and nutrition of rice as well as richer soil health.

Key words: Control farming, organic farming, conventional farming, physicochemical properties and nutrients of soil, nutritional values and mineral contents of rice.

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1. Introduction

Agriculture is the backbone of economy, employment and food security in Myanmar. Soil is used in agriculture, where it serves as the primary nutrient base for plants. The present concern about the soil fertility degradation, soil erosion and environmental pollution due to the high inorganic fertilization is an important issue. Organic fertilizers are used to preserve the soil structure and provide food for soil microorganisms. Moreover, nutritional value of rice varies slightly depending on rice varieties, harvesting, processing method, soil conditions and types of fertilizers. Appropriate good agricultural practices need to be applied when growing rice. Organic farming is an agricultural method that promotes the use of natural fertilizers, pesticides, fungicides and animal feed. In addition, it is the practice of crop rotation and the introduction of beneficial pests to maintain soil productivity. Conventional or inorganic farming uses pesticides, herbicides, fungicides and harmful chemicals to produce the food. It has damaged environment by contaminating rivers, lakes, drinking water and clouds forming rain. These poisonous chemicals have killed not only insects but also fish, birds, useful small animals, microorganisms and some plants. And then these agriculture chemicals are killing humans too. Soil is described from Latin word *solum*, which means the upper layer of the earth in which plants grow. It is a natural body consisting of layers (soil horizons) of mineral constituents of variable thickness which differ from the parent materials in their morphological, physical, chemical and mineralogical characteristics (Gattani, *et.al.*, 1976).

Many soils have vast reserves of plant nutrients but only a small portion of these nutrients becomes available to plants during a year or cropping season. Plants need 16 elements for their growth and completion of life cycle. Only three macronutrients are required by all plants: carbon, hydrogen and oxygen. These nutrients are supplied by water and carbon dioxide (Bolt, 1970). The remaining thirteen elements are obtained largely from the soil. The nutrients required in large quantities are known as macronutrients such as N, P, K, Ca, Mg and S. The macronutrients are consumed in larger quantities and are present in plant tissue in quantities from 0.15 % to 6.0 % on a dry matter (0% moisture). The nutrients which are required in small quantities (traces) are known as micronutrients or trace elements such as Fe, Zn, Cu, Mn, B, Mo and Cl. Micronutrients are consumed in smaller quantities and are present in plant tissue on the order of parts per million (ppm), ranging from 0.15 to 400 ppm, or less than 0.04%.

2. Materials and Methods

The field study, including the collection of soil and rice samples from organic, conventional and control farming in Taungoo University Farms were implemented. Firstly, the land was prepared well by three ploughings followed by leveling in organic, conventional and control farms. In organic farming, only organic manures and animal waste were utilized to prepare the land. During the land preparation and pudding, 0.5 ton of black gram straw residue along with 2.0 tons of paddy straw and animal waste especially cattle manure to be incorporated. In conventional farming, chemical fertilizers were applied to prepare the land. During land preparation and pudding, $^{3}\!/_{4}$ of 1 bag of P-fertilizer (T-super, TSP, made in China) and $^{1}\!/_{3}$ of 1 bag of K-fertilizer (Muriate of Potash, MOP) to be incorporated. After two weeks of paddy cultivation, 1 bag of nitrogenous fertilizer (Urea) was spread on the plots. In control farming, without chemical fertilizers were applied to prepare the land. Pesticides were not used in the paddy cultivation from organic, conventional and control farming. During paddy cultivation, the planted weeds were controlled by inserting to the soils in all the farms.

Soil samples from organic, conventional and control farming before and after paddy cultivation in Taungoo University Farms was collected. Twenty numbers of soil samples from each locality were taken about six inches depth from the surface thoroughly mixed to provide one representative sample. The collected soil samples were air dried in shade. The air dried samples were ground with wooden pestle and mortar and passed through 2 mm sieve to separate the coarse fragments (> 2 mm). The sieved soil samples were stored in separate clean, dry containers and used for the determination of physicochemical properties and nutrients.

The moisture contents of the collected soil samples from control, organic and conventional farming were measured by oven drying method at 105 ºC. The moisture percent was represented by the loss in weight. Soil textures were determined by particle sizes analytical method. A particle size analysis yielded a general picture of the physical properties of soil. It also was the basis for assigning the textural class made *i.e.*, whether a soil is sand, clay, loamy soil and so on. Organic carbon and humus of the soil were determined by using titration methods. Soil pH was measured for its acidity or alkalinity by pH meter (pH 300, Singapore).

The amount of soil nitrogen released by Kjeldahl method. The content of available phosphorus was measured by spectrophotometer (Ciba, Corning 259). Potassium content was determined by emission flame photometer (Jenway, PFP 7/C, England). The contents of magnesium and calcium were determined by using titration methods. Iron content was measured by atomic absorption spectrophotometer (Perkin Elmer Analyst – 300 AAS, Germany).

Rice samples were collected as the paddy rice arrived from organic, conventional and control growing areas after paddy cultivation in Taungoo University Farms. Firstly, paddy rice was dehusked by a rubber roll sheller to produce brown rice. The outer tough protective coating was removed because it was indigestible.

This has no effect on the nutritional composition of the grain that lies within the husk. The brown rice was further milled to produce white rice. The resultant white rice samples were stored in separate clean and dry containers. Then the nutritional values and mineral contents of rice samples were determined.

The nutritional values of the collected rice samples from control, organic and conventional farming were determined by AOAC methods such as moisture content by oven drying method, ash content by muffle furnace dry ashing method, protein content by Kjeldahl method, crude fiber content by solvent extraction method and crude fat content by soxhlet extraction method (AOAC, 2005). The mineral contents of the collected rice samples such as potassium, sodium, calcium, magnesium and iron were determined by atomic absorption spectrophotometer (Perkin Elmer Analyst – 300 AAS, Germany).

3. Results and Discussion

Measured values for physicochemical properties such as moisture, texture, pH, organic carbon, humus of soil samples from organic, conventional and control farming before paddy cultivation in Taungoo University Farms were shown in Table 1. The moisture contents of soil samples in organic, conventional and control farming were found to be 13.57%, 11.56% and 11.50 % respectively. The required amount of moisture should be exceed in the range of 12 to 20 % (Pandey, *et al*., 1985). The moisture content of organic farming was higher than conventional and control farming due to addition of organic manures which were responsible for significant increase in water holding capacity of soil. Soil types of organic, conventional and control farming were observed to be clay loam, loam and clay before paddy cultivation. Paddy is mostly cultivated on clay soil in Myanmar because clay soil retained moisture and plant nutrients well.

The soil pH of organic, conventional and control farming were found to be 5.00, 4.16 and 5.61 which indicated strongly, extremely and medium acidic soils due to the rainy season. Under condition in which rainfall exceeds leaching during rainy season, the basic soil cations (Ca, Mg, K) are gradually depleted and replaced with cations held in colloidal soil reserves, leading to soil acidity. Paddy can grow well in soil pH ranging from 5.0 to 8.0. The starter dose of sufficient lime fertilizer should be used as basal dressing in conventional farming in order to improve the buffering of soil pH before paddy cultivation. The data on organic carbon and humus of soil samples from organic farming (1.25%, 2.17 %), conventional farming (1.00 %, 1.74 %) and control farming (0.70 %, 1.22 %). The increase in organic carbon and humus contents of soil under organic farming were observed due to addition of organic manures which were responsible for the building up of organic carbon in soil. The symbiotic relationship between plant and soil focusing on sustainable plant production and nutrient management was promoted due to organic farming practice.

Table 1. Physicochemical Properties of Soil Samples before Paddy Cultivation in Taungoo University Farm

Constituents	Soil Samples		
	Organic Farming	Conventional Farming	Control Farming
Moisture (%)	13.57	11.56	11.50
Texture	Clay loam	Loam	Clay
Sand (%)	25.30	32.10	8.00
Silt (%)	42.50	45.60	20.80
Clay (%)	30.10	20.50	70.00
Total (%)	97.90	98.20	98.80
pH	5.00	4.16	5.61
Organic carbon (%)	1.25	1.00	0.70
Humus (%)	2.17	1.74	1.22

The nutrient values of soil sample in organic farming on available N (0.28%), P (0.0017 %), K (0.0135 %), Ca (0.1378 %), Mg (0.0226 %) and Fe (0.0008 %) were presented in Table 2. While the soil sample under conventional farming, N (0.26 %), P (0.0004 %), K (0.0116 %), Ca (0.1252 %), Mg (0.0303 %), Fe (0.0023 %) and the soil sample under control farming, N (0.22 %), P (0.0006 %), K (0.0078 %), Ca (0.2254 %), Mg (0.0526 %), Fe (0.0031 %) were observed. The increase in N, P and K contents of soil under organic farming were observed by the decomposition of organic manures.

The increase in available nitrogen due to organic matter application is also attributable to the greater multiplication of soil microbes caused by the addition of organic materials which mineralize organically bound N to conventional form. N increases the growth and development of all living tissues and the protein content of food grains. N deficiency symptom shows the leaves become yellowish and fall quickly. Similar observations of increase in available P and K of soil due to addition of organic manures were observed. P needs for meristematic growth, seed and fruit development, stimulates flowering. The deficiency of P appears dark green and plants stunted. K assists carbohydrate translocation, synthesis of protein and maintenance of its stability, membrane permeability and pH control, water utilization by stomatal regulation. The deficient K causes the shriveled seeds or fruits and chlorosis along the leaf margins followed by scorching. The highest contents of Ca, Mg and Fe were found in control farming. As control farming was medium acidic soil (5.61 of soil pH), it indicates the fact that the amount of secondary macronutrient and micronutrients are greater than those in the other two farming.

Ca is essential nutrient for membrane stability and maintenance of chromosome structure. The deficient Ca indicates that leaves become small, distorted and dark green. Ca deficiency effects associated with high acidity limit growth. Mg helps in the movement of sugars with plants. The deficient Mg shows that leaves usually small and brittle in final stages. Fe is the essential component of many enzymes and maintenance of chlorophyll in plants. The deficiency of Fe results in chlorosis and the entire leaf turns yellow.

Table 2. The Contents of Macronutrient and Micronutrient of Soil Samples before Paddy Cultivation in Taungoo University Farm

Nutrients	Soil Samples			Uptake of Plant* (%)
	Organic Farming	Conventional Farming	Control Farming	
NH_4^-, NO_3^- %	0.28	0.26	0.22	1.5
$H_2PO_4^-$, HPO_4^{2-} %	0.0017	0.0004	0.0006	0.1 – 0.4
K^+ %	0.0135	0.0116	0.0078	1.0 – 5.0
Ca^{++} %	0.1378	0.1252	0.2254	0.2 – 1.0
Mg^{++} %	0.0226	0.0303	0.0526	0.1 – 0.4
Fe^{++} %	0.0008	0.0023	0.0031	0.005 – 0.025

* Roy *et al*., (2006)

The results of rice nutrients such as moisture, ash, protein, crude fiber, crude fat, carbohydrate and energy value (calories) in organic, conventional and control farming were presented in Table 3. The experimental data pointed out that, moisture contents of organic, conventional and control rice were 11.11 %, 10.88 % and 11.72 %. Moisture assays can be one of the most important analyses performed on a food product. Water assists with the transport of materials in the body by marking up most of the liquid part of blood and helps breakdown food in the digestive system. The ash contents of organic, conventional and control rice were found to be 0.58 %, 0.65 % and 0.65 %. The results indicated that the ash content decreased under organic rice compared to conventional and control rice. A typical amount of ash from white rice should be exceed 0.6 % (USDA, 2009). Ash refers to the inorganic residue remaining after either ignition of organic matter in a foodstuff. Protein contents of organic, conventional and control rice were 8.59 %, 7.66 % and 6.99 % respectively. Comparison of protein content showed that its content was increased in the rice under organic farming which contained higher the available N in the soil than conventional and control farming. A typical content of protein in the white rice is 7.1 % (USDA, 2009). Protein is used to build muscle and fight infections. The higher amount of fiber (2.14 %) in organic rice was observed when compared with the amounts of fiber (1.92 % and 0.00 %) in conventional and control rice. The crude fiber is the organic residue left after the defatted material. Fiber helps digestion. It can also reduce colon cancer and diabetes. The fat contents of organic, conventional and control rice were (0.49 %, 1.08 % and 1.40 %). The fat content in organic rice was decreased when compared to conventional and control rice. Rice is an excellent food source, low in fat and rich in protein. In fact, organic rice is better than conventional and control rice. Carbohydrate of organic rice was 77.09 % whereas carbohydrate of conventional and control rice were 77.81 % and 79.24 %. Carbohydrate are broken down into sugar during digestion, most of which is used as energy for muscles and as essential fuel for the brain. The results on energy value of organic, conventional and control rice were 347.13 kcal/ 100 g, 351.60 kcal/100 g and 353 kcal/100 g. A little decrease in energy value of organic rice which contained the lower amount of fat and carbohydrate compared to conventional and control rice. The energy obtained from carbohydrate, protein and fat is, measurement in units, called calories. Calories give energy which needs them to be able to do work and be active.

Table 3. Nutritional Values of Rice Samples from Organic, Conventional and Control Farming

Test Parameter	Rice Samples		
	Organic Rice	Conventional Rice	Control Rice
Moisture (%)	11.11	10.88	11.72
Ash (%)	0.58	0.65	0.65
Protein (%)	8.59	7.66	6.99
Crude fiber (%)	2.14	1.92	0.00
Crude fat (%)	0.49	1.08	1.40
Carbohydrate (%)	77.09	77.81	79.24
Energy value (k cal / 100 g)	347.13	351.60	353

Minerals are conventional substances that are required in small amounts by human body in order to develop and grow properly. The experimental data in Table 4 pointed out that, the mineral contents such as K, Na, Ca, Mg and Fe of organic rice were 61.55, 28.14, 7.759, 11.76 and 2.635 ppm. While in the conventional rice, they were 61.59, 21.90, 8.180, 11.33, 2.956 ppm and control rice were 123.6, 47.21, 2.134, 10.33, 4.189 ppm respectively.It was observed that the slightly decrease in K, Ca and Fe contents of organic rice due to the nutrients in organic manure fertilizer are slow-release fertilizer and also much less readily available to plants. K helps the body reduce toxin and assists with the normal functioning of muscles and nerves. Ca is needed for strong bones and teeth. It also regulates blood clotting. Fe helps build hemoglobin which is the oxygen carrying in the blood. The results showed the slightly increase in Na and Mg contents of organic rice. Na helps to stay healthy for heart and kidney. Na is a component of salt. Therefore, consuming too much sodium may lead to high blood pressure. The USDA recommends limiting sodium intake to 2300 mg per day. Mg involves in the metabolism of proteins and carbohydrates. It also assists with bone growth and proper muscle functioning.

Table 4. Mineral Contents of Rice Samples from Organic, Conventional and Control Farming

Mineral (ppm)	Rice Samples		
	Organic Rice	Conventional Rice	Control Rice
K	61.55	61.59	123.6
Na	28.14	21.90	47.21
Ca	7.759	8.180	2.134
Mg	11.76	11.33	10.33
Fe	2.635	2.956	4.189

The comparative results of moisture, texture, pH, organic carbon, humus of soil samples before and after paddy cultivation in organic, conventional and control farming were represented in Table 5. From the experimental data, moisture contents after paddy cultivating soil areas of organic, conventional, and control farming reduced from 13.57 % to 7.16 %, 11.56 % to 6.18 % and 11.50 % to 10.61 % due to uptaking by paddy plants for their crop growth and plant height.

But the moisture content of control farming is higher than organic and conventional farming after paddy harvesting. Because of an increase in humus from control farming resulting from organic manures, decomposition facilitates to improve water holding capacity. The texture of soil sample in organic, conventional and control farming became clay loam to silt loam, loam to silty clay and clay loam to silty clay loam after harvesting. These results showed that the soil texture of organic farming is better than other farming. Because of improvement in soil texture by application of organic manures in organic farming was recorded.

After harvesting, pH values of organic, conventional and control farming became 5.74, 4.37 and 5.11. An increase in pH with addition of organic manures in organic farming might be due to the presence of colloidal matter in organic manures which improved the buffering capacity of soil. From the research data in Figure 1, the higher amount of organic carbon and humus in organic, conventional and control farming were 1.44 % and 2.48 %, 1.30 % and 2.24 %, 2.51 % and 4.33 % after harvesting. This finding revealed that many of the common arable weeds were controlled by inserting into the soil in all the farms. The inserting weeds process was similar to the addition of organic manure. It was quite obvious since an increase in organic carbon and humus after organic manures decomposition.

Table 5. Physicochemical Properties of Soil Samples before and after Paddy Cultivation in Taungoo University Farm

Constituents		Soil Samples		
		Organic Farming	Conventional Farming	Control Farming
Moisture (%)	Before	13.57	11.56	11.50
	After	7.16	6.18	6.61
Texture	Before	Clay loam	Loam	Clay
	After	Silt loam	Silty clay	Silty clay loam
pH	Before	5.00	4.16	5.61
	After	5.74	4.37	5.11
Organic carbon (%)	Before	1.25	1.00	0.70
	After	1.44	1.30	2.51
Humus (%)	Before	2.168	1.735	1.22
	After	2.48	2.24	4.33

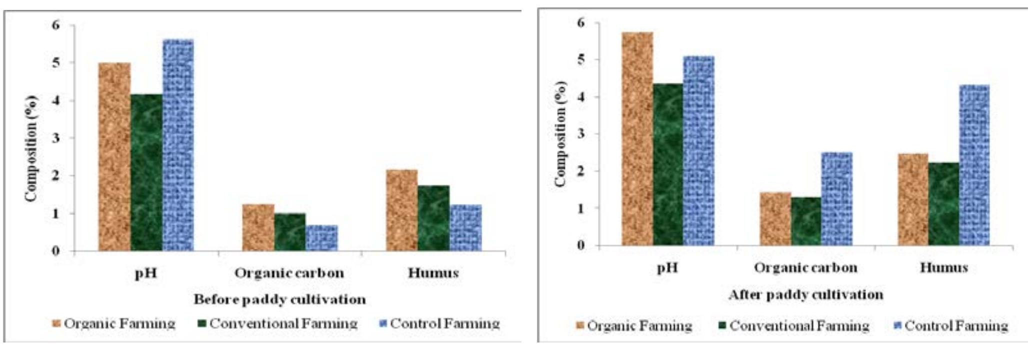

Figure 1. Histogram of pH, organic carbon and humus of soil samples before and after paddy cultivation in organic, conventional and control farming

The measured values of macronutrients and micronutrients of soil samples before and after paddy harvesting in all the farms were shown in Table 6 and Figure 2. It was found that after paddy harvesting, soils in organic, conventional and control farming were low in available N (0.24 %, 0.21 %, 0.20 %), P (0.0008 %, 0.0003 %,0.0004 %), K (0.0123 %, 0.0112 %, 0.0051%) and Ca (0.0810 %, 0.0112 %, 0.0056 %) contents due to uptaking by paddy plants for rapid growth, grain protein content, root development, regulation of cellular pH and enzyme activation. Although decrease in available N, P, K and Ca contents in all the farms, increase in these contents in organic farming after paddy harvesting. It is because microbes decompose from the organic manures to mineral elements which are converted into available plant nutrients through mineralization process in organic farming. With organically managed soils, soil nutrients are released slowly over time. Whereas the used chemical fertilizers are easily water soluble, this may lead to various types of losses through leaching, evaporation etc., in conventional farming. There was no appreciable change in Mg content of organic soil whereas the decrease in Mg contents of conventional and control soil is found after paddy harvesting. The used potassium fertilizer can reduce the magnesium content and indirectly can reduce the phosphorus content of the conventional soil. The higher amount of Fe in organic, conventional and control farms were observed to be 0.0019 %, 0.0041 % and 0.0037 % after paddy harvesting. A large amount of Fe in all the soils was observed because of P, Ca and K deficiency which associate with low soil base contents.

In view of this, organically managed soils were attributed to greater soil water content; higher nutrient availability and more protection from erosion compared to conventional and control treatments. In addition, the organic rice produced from organic farm was richer in protein, fiber contents and lower fat content than conventional and control rice. So, organic fertilizers influenced the better quality, safety and nutrition of rice as well as the healthier soil.

Table 6. The Contents of Macronutrient and Micronutrient of Soil Samples before and after Paddy Cultivation in Taungoo University Farm

Nutrients (%)		Soil Samples		
		Organic Farming	Conventional Farming	Control Farming
NH_4^+, NO_3^-	Before	0.28	0.26	0.22
	After	0.24	0.21	0.20
$H_2PO_4^-$, HPO_4^{2-}	Before	0.0017	0.0004	0.0006
	After	0.0008	0.0003	0.0004
K^+	Before	0.0135	0.0116	0.0078
	After	0.0123	0.0112	0.0051
Ca^{++}	Before	0.1378	0.1252	0.2254
	After	0.0810	0.0112	0.0056
Mg^{++}	Before	0.0226	0.0303	0.0526
	After	0.0226	0.0075	0.0168
Fe^{++}	Before	0.0008	0.0023	0.0031
	After	0.0019	0.0041	0.0034

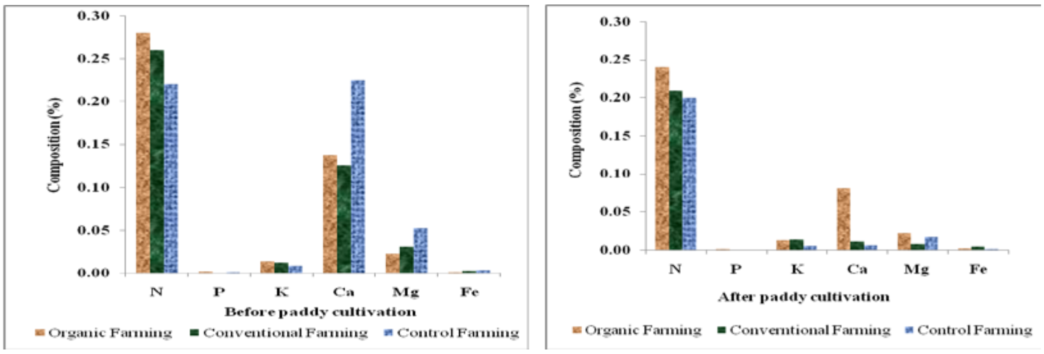

Figure 2. Histogram of N, P, K, Ca, Mg and Fe contents of soil samples before and after paddy cultivation in organic, conventional and control farming

4. Conclusion

The relation between the different agricultural farming and soil nutrients as well as rice nutrients before and after paddy cultivation in Taungoo University Farms has been assessed from the present research work.

The experimental data pointed out that moisture content of soil before paddy cultivation in organic, conventional and control farming were found to be 13.57 %, 11.56 % and 11.50 % and these amounts were sufficient to cultivate paddy plants. After paddy cultivation, an increase in moisture content (10.16 %) under control farming due to the higher amounts of organic carbon and humus. Soil under all the farms after paddy harvesting became an increase in soil texture from clay loam to silt loam, loam to silty clay and clay to silty clay loam by inserting weeds as green manures into the soils during paddy cultivation. Soil pH of organic, conventional and control farming were observed to be 5.00, 4.16 and 5.61 before paddy cultivation. Soil pH of organic and control farms were more suitable for paddy planting than conventional farming. After harvesting, the comparative results indicated that an increase in soil pH (5.74) under organic farming by the effect of organic manures to improve the buffering capacity of the soils. The higher amounts of organic carbon and humus in all the farms were 1.44 % and 2.48 %, 1.30 % and 2.24 %, 2.51 % and 4.33 % after paddy harvesting. This finding revealed that the inserting weeds as organic manures decomposed to increase in organic carbon and humus under all the farms.

It was found that after paddy cultivating soils under organic, conventional and control farming were low in available N (0.24 %, 0.21 %, 0.20 %), P (0.0008 %, 0.0003 %, 0.0004 %), K (0.0123 %, 0.0112 %, 0.0051 %), Ca (0.0810 %, 0.0112 %, 0.0056 %) and high in Fe (0.0019 %, 0.0041 %, 0.0037 %) contents when compared with before paddy cultivating soils in all the farms. In spite of the decrease in available N, P, K and Ca contents in organic farming, there is an increase in these contents except Fe in organic farming after compared to conventional and control farming paddy harvesting. These results showed the fact that it is due to reducing soil erosion by organic manures.

The collected rice samples under organic farming recorded higher amounts of protein and fiber (8.59 % 2.14 %) than the rice under conventional and control farming, they were0.65%, 7.66 % and 0.65 %, 6.99 %. In addition, low in fat(0.49 %), carbohydrate (77.09%) and energy value (347.13 kcal) were observed in organic rice when compared with conventional and control rice contained 1.08 %, 77.81 %, 351.60 kcal and 1.40 %, 79.24 %, 353 kcal. Especially, rice is an excellent food source rich in protein and low in fat. In fact, organic rice is better than conventional and control rice. A slightly decrease in K, Ca, Fe contents and an increase in Na, Mg contents in organic rice were observed.

According to the context, using easily available local natural resources organic farming can be practiced with a view to protect environment for a fertile soil and quality food. Given the same profitability, organic farming is more advantageous than conventional and control farming, considering its contribution to health, environment and sustainability.

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