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The Influence of Different Mulching on the Productivity of Lettuce (*Lactuca sativa L.*)

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Abstract— *The study entitled "The Influence of Different Mulching Materials to Soil Physical Properties and on the Growth and Development of Lettuce (Lactuca sativa L.) was conducted at the Western Mindanao State University, College of Agriculture, San Ramon, Zamboanga City. The objectives of the study were: 1.) To evaluate the effect of different mulching materials on the growth and yield of leaf lettuce, 2.) To determine the influence of different mulching materials on the soil's physical properties and with a general objective of determining what kind of mulching material would give a good response to the growth and development of leaf lettuce and which one would improve the soil's physical properties. The study was carried out in Complete Randomized Block Design (RCBD) with four treatments and replicated three times. Treatments were as follows: T1 – No mulch, T2– Polyethylene black sheet, T3 – Rice Straw, and T4 – Nipa Leaves. The parameters used to determine the effect of the different treatments were; plant height, the average number of leaves, leaf area index, average yield per plot, soil temperature, soil moisture, weed growth magnitude, and earthworm count. The plant height, average number of leaves, leaf area index, and average yield per plot of lettuce show no significant difference, suggesting that the different mulching materials did not influence the growth of lettuce The soil moisture content as influenced by the different mulches was significant. Nipa leaves followed by rice straw have the highest soil moisture content among the different treatments. It is suggesting that organic mulch is efficient in conserving water. The weed growth magnitude as influenced by the different mulches was highly significant. The lowest number of weeds was recorded in the polyethylene black sheet followed by the nipa leaves. The result proved that plastic mulch is effective in suppressing weed growth. The earthworm count found in the different mulching materials was significant; the highest count was found in control and organic mulches.*

Keywords— *ANOVA, RCBD, Mulching, Growth, Yield*.

I. INTRODUCTION

Lettuce (Lactuca sativa L.) is widely cultivated in temperate areas for its cool climatic requirements. The Filipino farmers tried and have succeeded to plant lettuce even though the climate is not suited for production. However, the production is still low to meet the weekly market demand of 90 metric tons (Uesebio, 2003).

Leaf Lettuce is an herbaceous annual or biennial crop. It is usually grown as a leaf vegetable with a height of 30 cm. The root depth is 18 - 30 inches while taproots can grow to 5 inches (Lettuce Growing and Harvest Information, 2008). All types of lettuce grow best in cool areas. The optimum temperature ranges from 15 to 18 ˚C. Lettuce is also adapted in areas with a relative humidity of 65 to 85 %. Lettuce grows best in soil with a pH of 6 to 6.8 and in silty clay loam, loam, and clay loam soils. Soils with high organic matter are preferred for good water-holding capacity.

Based on physiological structure, lettuce is composed primarily of water. When the weather is hot and dry, lettuce losses moisture rapidly which causes heat stress. Proper spacing and mulching can control heat stress by cooling the microclimate around the plants and slowing water loss (Problem of Lettuce,2003).

Mulching is one cultural practice that can be used to address problems in soil that relate to lettuce production. Covering the ground with mulch saves water by preventing surface evaporation. The layer can also greatly reduce or eliminate weed propagation, which will also result in higher water use efficiency (Mcmillen, 2013). Mulches are used primarily to increase water infiltration, reduce evaporation by about 35% compared to bare soil (Chalker-Scott, 2007), modify soil temperatures, control weeds, and increase crop yields. They also increase the biological activities in the soil, modify the level of available nutrients, and help to maintain or increase the level of soil organic matter (Development in Soil Science, 1973).

Because mulching is widely used in agricultural practices for a long time for its usefulness, using mulching materials abundant in the area such as rice straw, and nipa leaves will be used in the study to determine which of these materials will provide the micro-climatic preference for good growth of lettuce in the warm climate area.

Site selection and time of study

The study was conducted at Western Mindanao State University, College of Agriculture San Ramon, Zamboanga City, Philippines.

Zamboanga City Map

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II. MATERIALS AND METHODS

Materials

The materials used in the study were the following: Lettuce Seeds, polyethylene back sheet, rice straw, water can, soil thermometer, oven, tin can, weighing scale, ruler, tarpaulin, record notebook, and pen/pencil.

Methods

Experimental Design and Treatment

The experimental field was laid out in Randomized Complete Block Design (RCBD) with four treatments replicated three times. The following treatments were.

T_1- No Mulching (Control) T_2- Polyethylene Sheet

T_3- Rice Straw , T_4- Nipa Leaves

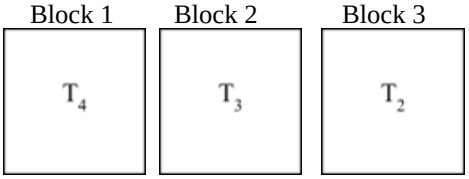
Soil Sampling and Analysis

Soil samples were taken in a zigzag method from the area and were air-dried for seven days. The dried soils were sifted at 2.0mm size and packed in a sealed plastic bag. This was brought to the Department of Agriculture Bureau of Soil Laboratory for soil analysis purposely for fertilizer recommendation rate.

Land Preparation

The area was cleared of weeds and unnecessary materials. After clearing, it was plowed and harrowed twice until the soil became pulverized. The area was laid out into tree blocks and each block has four plots where treatments were observed.

Field Layout



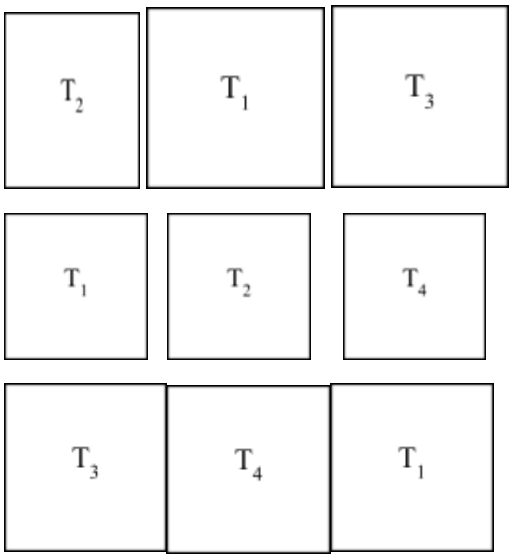


Figure 1. Field Layout (RCBD)

Total Experimental Area = 135 m^2 Dimension per Plot = 9 m^2 Distance between Blocks = 0.5 m^2 Distance between Treatment = 0.5 m^2 Number of Plots =12

Legends:

T_1– No Mulching

T_2– Polyethylene Sheet

T3- Rice Straw

T_4 – Nipa Leaves

Seedling Preparation

A seedbed was used for the seedling preparation. The seedbed was mixed with vermicast. After seedbed preparation, the seeds were sown thinly and equally distributed. Water was regularly applied to maintain sufficient soil moisture.

Pricking and Hardening

The seedlings were pricked and hardened using banana leaves as burlap two weeks after sowing. The seedlings were gradually exposed to the sun for one week before transplanting to minimize transplanting shock.

Transplanting

Seedlings were transplanted 21 days after sowing, with a distance of 30 cm between hills and 30 cm between furrows. After transplanting, water was provided to minimize wilting and avoid the death of newly transplanted seedlings.

Mulching

Polyethylene black sheets were spread before the transplanting. The polyethylene black sheets were laid on the beds tightly by burying their edge in the soil. Planting holes were established according to or based on 30 X 30 cm planting distance.

The rice straw mulches were placed between the plants at least two inches thick.

The rice straw was spread equally around the crop covering all the beds.

For nipa leaves, the nipa leaves were carefully arranged into the soil beds to completely cover the ground surface. The leaves were clipped with bamboo slits to prevent disarrangement and being blown by the strong wind.

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Fertilization

For basal application, two kilograms of commercial organic fertilizer per plot were broadcasted and mixed into the soil. Side dressing of vermicast was done two weeks after transplanting.

Watering

Watering of plants was done every morning and afternoon from transplanting to harvesting using a sprinkler.

Weeding

Weeding was done by pulling or by "hilamon" once every two weeks to prevent weed proliferation in the beds.

Insect Pest Management

Insect infestation and disease infection were daily monitored to determine the need of spraying chemical pesticides.

Harvesting

Harvesting was done 40-60 days after sprouting. Harvesting was done by cutting off the plant base just above the soil surface.

Statistical Analysis

SAS software using a computer was used to calculate all statistical analysis.

Data Gathered

The following is the data gathered:

Plant Height

This was done by measuring the sixteen (16) sample plants per plot from the base up to the highest tip of the plant.

Average Number of Leaves

This was done by counting the leaves of sixteen (16) sample plants per plot.

Leaf Area Index

This was done by measuring the leaf width, leaf length, and leaf canopy of the biggest leaf in the sample plant. It was computed using the formula of Leaf area index = leaf area (cm2)/land area (cm2) (Edje, O.T. and Ossom, 2009).

Average Weight per Plot

This was done by weighing all the marketable lettuce per plot.

Soil Temperature

This was done using a soil thermometer by measuring the temperature of the soil during the hottest hour of the day.

Soil Moisture

This was done by collecting soil samples from the plot using a tin can. The soil was weighed and oven dry for 24 hours. The soil moisture content was calculated as a percentage of dry soil weight.

$$MC\% = \frac{\quad}{W_3 - W_1} X\ 100$$

Where:

W_1 = weight of tin (g)

W_2 = weight of moist soil + tin (g) W_3 = weight of dried soil + tin (g)

(Soil Survey Standard Test Method Soil Moisture Content, 1990)

Weed Growth Magnitude

This was done using a 1 x 1m quadrant placed randomly in the bed and counting all weeds inside the quadrant.

Earthworm Count per Plot

This was done by diluting 5 ml of formalin in 1 liter of water and drenching inside a 1x1m quadrant. Count all the worms that will appear on the surface.

III. Results and Discussion

Plant Height

The plant height of lettuce measured in centimeters as influenced by different mulching materials is shown in Table 1. As noted in the data, plants without mulching (T_1), obtained the highest mean of 18.98 cm. This was followed by nipa leaves (T_4) and polyethylene black sheet (T_2) with a mean of 16.31 cm and 15.78 cm respectively. The lowest plant height with a mean of 14.41 cm was observed in the rice straw (T_3).

The result shows no significant difference between the treatments. This means that the different mulching materials namely nipa leaves, rice straw, and polyethylene black sheet did not influence the height of the lettuce. Their performance was similar when compared to the control. This could also mean that the experiment failed to detect differences among treatments.

The non-significant result of the plant height of lettuce may be due to the variety of lettuce used which was Green Span. Green Span variety of lettuce has a good tolerance to heat and dry seasons that are genetically engineered to grow in the harsh climate of the country. This variety of lettuce can grow vigorously by providing its essential needs without the help of mulching.

Average Number of Leaves

Table 2 shows the number of leaves per plant of lettuce as influenced by the different mulching materials. As shown in the table, lettuce plants without mulching (T_1) obtained the highest number of leaves with a mean of 21 leaves. This was followed by nipa leaves (T_4) and polyethylene black sheet (T_2) with a mean of 18 and 16 leaves respectively. The lowest number of leaves was obtained in rice straw (T_3) with a mean of 15 leaves per plant. The result shows no significant difference among the treatments as shown by the analysis of variance. The result indicates that the different mulching materials had no variation to influence the number of leaves of lettuce.

Leaf Area Index

The leaf area index of lettuce is presented in Table 3. As noted in the tabulated data, nipa leaves (T4) mulch has the highest mean of 0.40. This was followed by a polyethylene black sheet (T2) with a mean of 0.37. While control (T1) and rice straw (T3) have the same mean of 0.37. However, the results showed that there is no significant difference between the control and the other treatments in the parameter measured. It indicates that the different mulching materials did not influence the leaf area index of the lettuce. Leaf area index or leaf surface per ground cover is one of the major controls on plant productivity and biospheric feedback on atmospheric energy and water exchange.

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The result is contrary to the finding of Kumar et al., (2014) that full leaf expansion could lead to maximum green leaf area index of soil temperature increases, as in the experiment that soil temperature is increasingly affected.

Average Yield per Plot

Table 4 shows the average yield per plot of lettuce as influenced by the different mulching materials. As shown in the table, control (T_1) has the highest average yield mean of 2553.03 grams. This was followed by polyethylene black sheet (T_2) and nipa leaves (T_4) with a mean of 2101.6 grams and 2076.93 grams respectively. The lowest average yield was obtained in rice straw (T_3) with 1740.07 grams.

The result shows no significant difference within the treatment. It indicates the failure of the experiment to detect any difference among the treatments.

The non-significant result may be due to the damage of leaf lettuce in the organic mulch treatments during the rainy seasons. This assumption was based on the presence of leaf folders and fungus that infected the leaf of the lettuce, especially on the rice straw mulch. The observed low infestation on control and polyethylene black sheets of pests during the rainy season was an indicator that organic mulch can be served as a favorable environment (provide wet conditions) for the survival and multiplication of pests on the crops.

Soil Temperature

The average soil temperature as influenced by the different mulching materials is shown in Table 5. The table shows that polyethylene black sheet (T_2) has the highest soil temperature mean of 30.98˚C. This was followed by control (T_1) and rice straw (T_3) with the mean of 28.91˚C and 28.3˚C respectively. The lowest soil temperature was measured in nipa leaves (T_3) with a mean of 27.73˚C. Statistics show that there is a highly significant difference between the treatments. The result proved that soil temperature was significantly higher in polyethylene sheets. According to Tarara (2006), plastic mulches absorb a comparatively large amount of incoming radiation and transmit a considerable part of it to the soil underneath. The lowest soil temperature was obtained in nipa leaves. While organic mulching materials that cover the soil surface have a lower thermal conductivity that helps to reduce the solar energy reaching the soil surface, as a result, it reduces the soil temperature to increase during hot weather.

Soil Moisture

Figure 6 shows the average mean of soil moisture as influenced by the different mulching materials. As shown in the table nipa leaves (T_4) have the highest soil moisture content with a mean of 33.59%. This was followed by ice straw (T_3) and polyethylene black sheet (T_2) with a mean of 29.79% and 25.31% respectively. The lowest soil moisture was measured in control (T_1) with a mean of 22.93%.

The result shows that there is a significant difference between the treatments. The result proved that mulching can improve soil moisture retention. According to Dilipkumar *et al.* (1990), mulching reduces soil water evaporation. Thus, it enhances more retention of soil moisture more than bare soil. The reason may be that mulching materials block the droplets of water from evaporating through a collision of water vapor with the mulch as water vapor will drip back to the soil surface and keep the moisture within the mulch area. Among the treatments, nipa leaves and rice straw are shown to have higher moisture content than the polyethylene black sheet. It is suggesting that organic mulch is more efficient in conserving water than plastic mulch.

Weed Growth Magnitude

The mean of weed growth magnitude as influenced by the different mulching materials is shown in Table 7. Control (T_1) has the highest mean of 199.25. This was followed by rice straw (T_3) and nipa leaves (T_4) with a mean of 79.08 and 16.38 respectively. The lowest number of weeds was counted in a polyethylene black sheet (T2) with a mean of 3.38 counts.

The result shows that there is a highly significant difference between the treatments. The result proves that among the mulches used the black polyethylene sheets are effective in suppressing weed growth. The weeds were only emerging from the side of the plants where they had a chance to survive. According to Toshio (1991), polyethylene sheets give effective weed control by cutting down solar radiation by more than 90%. It blocked the penetration of light to the soil, therefore no weed seedlings survive under black mulch. While the organic mulch has open pores for the light to pass through that will make the seeds of weeds germinate. As observed, rice straw can be a carrier of weeds because weed seeds can be stocked in between the straws.

Earthworm Count

The mean of earthworm count as influenced by the different mulching materials was shown in Table 8. Control (T_1) has the highest number of earthworms with a mean of 3.67. This was followed by nipa leaves (T_4) and rice straw (T_3) with a mean of 3.33 and 2.67 respectively. The lowest number of earthworms was obtained in polyethylene black sheet (T_2) with a mean of 0.67. Statistics show that there is a significant difference in earthworm count in the different mulching materials. The result shows that the number of earthworms in control, nipa leaves, and rice straw treatments have higher earthworms than the polyethylene black sheet. The soil in the experimental area is believed to have a sufficient organic matter content as a source of food for the earthworm, thus treatment without mulch and treatments with organic mulch performed similar earthworm counts.

Table 1. Transformed data on plant height (cm) of lettuce as influenced by the different mulching materials.

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	19.69	21.19	16.05	56.93	18.98
T2 - Polyethylene	15.53	14.06	17.74	47.33	15.78
T3 – Rice Straw	12.56	15.44	15.24	43.24	14.41
T4 – Nipa Leaves	19.48	13.65	15.81	48.94	16.31
Block Total	67.26	64.34	64.84		
Grand Total				196.44	
Grand Mean					16.37

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Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	1.22	0.61	0.09	0.92
Treatment	3	32.94	10.98	1.56^{NS}	0.29
Error	6	42.16	7.03		
Total	11	76.32			
Source					

NS – Not significant cv(%) = 16.19

Table 2. Transformed data on the average number of leaves of lettuce as influenced by the different mulching materials.

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	23.94	21.19	17	62.13	20.71 [a]
T2 - Polyethylene	17.38	13.50	17.88	48.76	16.25 [a]
T3 – Rice Straw	12.06	17.50	15.38	44.94	14.98 [a]
T4 – Nipa Leaves	24.38	13.69	13.50	51.57	17.19 [a]
Block Total	77.76	65.88	63.76		
Grand Total				207.4	
Grand Mean					17.28

Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	28.47	14.23	0.85	0.47
Treatment	3	54.35	18.12	1.09^{NS}	0.42
Error	6	100.05	16.68		
Total	11	182.87			

NS- Not significant
cv (%) = 23.63

Table 3. Transformed data on the leaf area index of lettuce as influenced by the different mulching materials.

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	0.35	0.33	0.43	1.11	0.37 [a]
T2 - Polyethylene	0.33	0.46	0.37	1.16	0.39 [a]
T3 – Rice Straw	0.39	0.37	0.35	1.11	0.37 [a]
T4 – Nipa Leaves	0.34	0.44	0.43	1.21	0.40 [a]
Block Total	1.41	1.6	1.58		
Grand Total				4.59	
Grand Mean					0.38

Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	0.00545	0.00272500	1.03	0.41
Treatment	3	0.00229167	0.00076389	0.29 ^{NS}	0.83
Error	6	0.01588333	0.00264722		
Total	11	0.02362500			

NS- Not significant
cv (%) = 13.45

Table 4. Transformed data on average yield per plot of lettuce as influenced by the different mulching materials.

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	2321.9	3085.6	2251.6	7659.1	2553.03 [a]
T2 - Polyethylene	1875.7	2765.6	1663.5	6304.8	2101.60 [a]
T3 – Rice Straw	1694.6	1968.4	1557.2	5220.2	1740.07 [a]
T4 – Nipa Leaves	2931.6	1677.7	1621.5	6230.8	2076.93 [a]
Block Total	8823.8	9497.3	7093.8		
Grand Total				25414.9	
Grand Mean					2117.91

Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	768609.54	384304.77	1.51	0.29
Treatment	3	1002129.01	334043.003	1.31^{NS}	0.35
Error	6	1528066.24	254677.71		
Total	11	3298804.79			

NS – Not significant
cv (%) = 23.83

Table 5. Transformed data on soil temperature as influenced by the different mulching materials on lettuce (*Lactuca sativa L.*)

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	28.82	29.36	28.55	86.73	28.91 [b]
T2 - Polyethylene	30.91	30.64	29.82	91.37	30.46 [a]
T3 – Rice Straw	28.45	28.09	28.36	84.9	28.3 [bc]
T4 – Nipa Leaves	27.36	27.91	27.91	83.18	27.73 [c]
Block Total	115.54	116	114.64		
Grand Total				346.18	
Grand Mean					28.85

Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	0.24	0.17	0.71	0.53
Treatment	3	12.45	0.12	24.47**	0.0009
Error	6	1.02	4.15		
Total	11	13.70			

** - Highly significant cv (%) =1.43

Table 6. Transformed data on soil moisture as influenced by the different mulching materials on lettuce (*Lactuca sativa L.*)

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	22.56	20.33	25.91	68.8	22.93 [b]
T2 - Polyethylene	25.47	22.17	28.29	75.93	25.31 [ab]
T3 – Rice Straw	38.85	25.85	24.68	89.38	29.79 [ab]
T4 – Nipa Leaves	35.60	32.79	32.39	100.78	33.59 [a]
Block Total	122.48	101.14	111.27		
Grand Total				334.89	
Grand Mean					27.91

Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	56.97	28.49	1.59	0.28
Treatment	3	202.12	67.37	3.76*	0.079
Error	6	107.41	17.90		
Total	11	366.51			

*- Significant cv (%) = 15.16

Table 7. Transformed data on weed growth magnitude as influenced by the different mulching materials on lettuce (*Lactuca sativa L.*).

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	111.75	114.5	126.5	357.75	119.25 [a]
T2 - Polyethylene	3.25	4.5	3.75	11.5	3.83 [c]
T3 – Rice Straw	80.25	69	88	237.25	79.08 [b]
T4 – Nipa Leaves	11	12.25	17.75	41	13.67 [c]
Block Total	211.25	200.25	136		
Grand Total				647.5	
Grand Mean					53.96

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Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	183.26	91.63	3.69	0.0901
Treatment	3	26443.94	8814.65	355.18 **	0.0001
Error	6	148.91	24.82		
Total	11	26776.10			

** - Highly significant cv (%) = 9.30

Table 8. Transformed data on earthworm count as influenced by the different mulching materials on lettuce (*Lactuca sativa L.*).

Treatments	Block			Total	Mean
	I	II	III		
T1 - No Mulch	4	5	2	11	3.67 [a]
T2 - Polyethylene	1	0	1	2	0.67 [b]
T3 – Rice Straw	3	3	2	8	2.67 [a]
T4 – Nipa Leaves	4	3	3	10	3.33 [a]
Block Total	12	11	8		
Grand Total				31	
Grand Mean					2.59

Analysis of Variance

Source of Variance	DF	SS	MS	FC	Pr > F
Block	2	2.17	1.08	1.44	0.308
Treatment	3	16.2	5.42	7.22 *	0.0204
Error	6	4.50	0.75		
Total	11	22.92			

*- Significant
cv (%) = 33.52

IV. Summary and Conclusion

The plant height, average number of leaves, leaf area index, and average yield per plot of lettuce show no significant difference, suggesting that the different mulching materials did not influence the growth of lettuce. The performance of the different mulches was similar to that of the control.

The soil temperature as influenced by the different mulching materials was highly significant. Soil temperature is significantly higher in polyethylene black sheets than with organic mulches and without mulch. This could mean that a polyethylene black sheet is a good absorber of heat from radiation.

The soil moisture content as influenced by the different mulches was significant. Nipa leaves followed by rice straw have the highest soil moisture content among the different treatments. It is suggesting that organic mulch is efficient in conserving water.

The weed growth magnitude as influenced by the different mulches was highly significant. The lowest number of weeds was recorded in the polyethylene black sheet followed by the nipa leaves. The result proved that plastic mulch is effective in suppressing weed growth. The earthworm count found in the different mulching materials was significant; the highest count was found in control and organic mulches.

Based on the findings of the study, it can be concluded that the different mulching materials improved the soil physical properties however the chemical reaction that increased the nutrient availability for the plants cannot be determined in a short period. The organic mulch is economically and environmentally sound while the plastic mulch will lessen work intensive. Although all the mulching materials have shown promise, farmers should consider the suitable time of applying each type of mulch for great success.

V. Recommendation

In line with the result, it is recommended to farmers use mulching as one of their farming practices however, the use of mulching materials will depend on the purpose of the farmer. To the researcher, it is also suggested that further research should be carried out to the following line:

1.) Other crops that have longer life span should also be researched on the different mulching materials to determine their influence on the growth and development of the crop.

2.) Kind of crops that are suitable for specific mulching materials.

3.) Kind of mulching materials that are suited to use in different seasons.

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