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Growth and Yield of Peanut (*Arachis hypogaea* L. var. NSIC Pn15) as Influenced by Different Thickness of Rice Hull and Rice Straw Mulch

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Abstract

Mulching materials control weeds and enhance the growth and yield of the crop. This study aimed to assess the effects of different thickness of rice hull and rice straw mulch as weed control on the growth, yield and profitability of peanut. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The treatments were: T_1- Control, T_2- Hand weeded and no mulch, T_3- Rice straw mulch (1 inch thick), T_4- Rice hull mulch (1 inch thick), T_5- Rice straw mulch (2 inches thick), and T_6 - Rice hull mulch (2 inches thick). Results revealed that application of rice hull and rice straw mulch at different thickness significantly affected the plant height (cm), leaf area index, fresh straw yield (tha^{-1}), number of seeds per pod and fresh pod yield (tha^{-1}) of peanut. Fresh and dry weight of weeds at 4 weeks after planting significantly reduced when mulched with rice straw at 2 inches thick (T_5). It resulted in more number of pods per plant, highest pod yield of 2.64 tha^{-1} and the highest gross margin of PhP 88,701.00 ha^{-1}.

Key words: Hand-wedding, organic mulching materials, weed control, yield and profitability

1. Introduction

Peanut (*Arachis hypogaea* L.) locally known as “mani” belongs to family Fabaceae. It has high protein content which ranges from 22-30% of its total calories, making peanut a great source of plant-based protein. It also also contains high amount of minerals, antioxidants and vitamins (riboflavin, niacin, vitamin B-6 and folates) (Jordan et al., 2017). In the Philippines, peanut is considered as one of the major field legumes grown by local farmers (Billen et al., 2015). However, its production has been low and erratic with a national average yield

ranging only from 800 to 1,000 kilograms per hectare. Nevertheless, peanut production remains profitable when proper cultural management is employed.

Weeds growing along with crops deplete considerable amount of nutrients and soil moisture resulting to poor crop growth. Hence, weed control is an important consideration in crop production. Studies (Ahmed et al., 2014; Akter et al., 2017; Pilapil, 2015). showed that mulching could be an effective cultural management in controlling weeds and conserving soil moisture. Mulches like rice straw and rice hull suppress weed growth and conserve soil moisture. They also suppress multiplication of weeds during the early stage of crop growth (Jodaugiene et al., 2016). Mulching as a method of weed control could be an alternative to herbicide application. It also helps build up the organic matter content of the soil as mulch decays and improves crop growth. Mulching can be done using indigenous and locally available materials like rice straws and rice hulls. These farm by-products are available in all rice farm communities and can be utilized not only to suppress weed growth, conserve soil moisture but also as sources of nitrogen especially when they are completely decomposed (Brandenburg et al., 2019). Moreover, according to Pilapil (2015), mulching was able to increase the length of main vines, leaf area index and fresh herbage weight of sweetpotato. The mulch is used to cover the soil before weeds can emerge to maintain good growth of peanut and other field crops (Akter et al., 2017). Moreover, the practice of mulching is important to minimize crop weed competition. Weed invasion reduces crop yield up to 70% depending on weed population.

Another advantage of mulching is that it reduces soil evaporation during dry periods as much as 75% (Pilapil, 2015). It also activates earthworm and helps aerate the soil. Weeding operation is time consuming. Out of the total labor input of African women in rice production, 40-60% is spent on weeding (Jodaugiene et al., 2016). When mulching is used, reduction on weeding expenses could be attained. This study was conducted to determine the thickness of rice hull and straw mulch materials that could effectively suppress weed growth and improve the productivity and profitability of peanut.

2. Materials and Methods

The study was conducted in an area with a size of 291.5 m^2 and Umingan clay loam soil (FAO, 2013) located at the Agronomy Experimental Area of the Visayas State University, Babay City, Leyte, Philippines. The experimental area has a GPS coordinates of 10°44' 59.8668" N, 124°47' 38.1264" E. It was plowed and harrowed twice at weekly interval using a carabao-drawn implement. Plowing and harrowing were done to allow the weeds to decompose, pulverize the soil, level the field, and provide time for weed seeds to germinate and incorporate them to the soil. Furrows were constructed at a distance of 0.5 m apart.

Soil samples were collected randomly from the experimental area before plowing. These were composited, air-dried, pulverized, sieved (2 mm wire mesh) and submitted to the Central Analytical Service Laboratory (CASL) of Philippine Root crops, Visayas State University, Visca, Baybay City, Leyte to determine the soil pH using Potentiometric method (1:2.5 soil water ratio), % organic matter using the Modified Walkley-Black method, total N using the micro Kjeldal method, extractable P and exchangeable K using 1:1 N ammonium acetate extraction method. For the final soil analysis, three samples were collected from each treatment plot after

harvest of peanut. Collected soil samples were air dried, composited and processed to determine the same soil parameters mentioned above. The experimental area was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each replication was divided into six treatment plots, measuring 3 m × 4 m with 1 m alleyways between replications and 0.50 m between treatment plots to facilitate farm operations and data gathering. The different treatments were designated as follows: T_1 - Control (unmulch and unweeded), T_2 - Hand weeded and no mulch, T_3 - Rice straw mulch (1 inch thick), T_4 - Rice hull mulch (1 inch thick), T_5 - Rice straw mulch (2 inches thick), T_6 - Rice hull mulch (2 inches thick).

Peanut seeds of variety NSIC Pn15 were sown in furrows spaced at 0.5 m apart and 0.20 m between hills at the rate of 2 seeds per hill to meet the desired plant population of 200,000 per hectare. Seeds were covered with thin layer of soil to protect them from ants and birds. Application of complete fertilizer (14-14-14) was done one week after seedling emergence at the rate of 30-30-30 kg ha^{-1} N, P_2O_5, K_2O. . The actual amount of complete fertilizer applied was 257.14 g per plot. The different mulching materials (rice straw and rice hull) were applied two weeks after planting. These materials were evenly distributed within each treatment plot in such a way that only peanut seedlings were exposed..

Aphids, worms and leafhoppers were controlled by spraying Karate at the rate of 2 tbsp per 16 liters of water after gathering data on pest. Hand weeding in designated plots was done after collection of weed data. Harvesting was done when 90% of the plants reached maturity. At this stage, the pods became firm and the crop exhibited yellowing and falling of leaves. One row in each side and one end hill served as border leaving two border rows in each treatment plot within the harvestable area of 7.2 m^2 were uprooted with the aid of bolo. Extra care was observed to minimize damage of pods. After which, peanut pods were handpicked, washed and dried to attain a moisture content of approximately 14%.

2.1. Data gathered

For agronomic characteristics, he data gathered include days from sowing to flowering, days from sowing to maturity, plant height (cm), and Leaf area index (LAI). LAI was computed using the formula:

$$\text{LAI} = \frac{\text{Total leaf area (TLA)}}{\text{Ground area } (2{,}500\ \text{cm}^2)}$$

$$\text{Where: TLA} = \sum (\text{L} \times \text{W} \times 0.552)$$

The correction factor (CF) of 0.552 for peanut variety NSIC Pn15 was established by Sarcol and Cagasan (2016).

Fresh herbage weight (t ha^{-1}) was converted to tons per hectare using the formula:

$$\text{Herbage yield } (t\ ha^{-1}) = \frac{\text{Plot herbage yield (kg)}}{\text{Harvestable area } (7.2\ \text{m}^2)} \times \frac{10{,}000\ \text{m}^2\ \text{ha}^{-1}}{1{,}000\ \text{kg t}^{-1}}$$

For yield and yield components, data gathered were: number of pods per plant, number of seed per pod, weight (g) of 1,000 seeds, fresh pod yield (t ha^{-1}), and harvest index (HI) which was determined using the formula:

$$HI = \frac{\text{Dry weight of seeds (g) 3 sample plants}}{\text{Dry herbage yield (g)+Dry weight of seeds (g)}}$$

There are only 3 parameters gathered on weeds such as: Weed population (No. plot-1) fresh weight of weeds (g quadrat-1) and dry weight of weeds (g quadrat-1).

For cost and return analysis, gross income and gross margin were computed using the formula:

Gross Income = Pod Yield (kg ha^{-1}) x Current Market Price kg^{-1} of Peanut

Gross Margin = Gross Income – Total Variable Cost

Meteorological data, which include total weekly rainfall (mm), average daily minimum and maximum temperatures (°C), and relative humidity (%) throughout the conduct of the experiment were obtained from the records of the Philippine Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) Station at the Visayas State University, Visca, Baybay City, Leyte. After gathering the data, means were computed and analysis of variance was done using the Statistical Tool for Agricultural Research (STAR). Comparison of means was done using Tukey's Test.

3. Results and Discussion

Agro-climatic data from planting to harvesting of peanut variety NSIC Pn15 are presented in Table 1. The climatic data, including the total amount of rainfall (mm), minimum and maximum temperatures, as well as the percent relative humidity received by the peanut plants were sufficient for its normal growth and development (PCARRD Handbook, 2002). Thus, the plants were able to produce good yield specifically in T_5 (plants mulched with Rice straw at 2 inches thick) which produced the highest yield of 2.64 tha^{-1} and obtained a reasonably high net income of PhP 88,701.00.

Table 1. Agro-climatic data during the duration of the study (April 21 to July 21, 2018) obtained from the PAGASA Station in VSU, Visca, Baybay City, Leyte.

Period	Total	Temperature (°C)		Relative
(Monthly)	Rainfall (mm)	Minimum	Maximum	Humidity (%)
April	8.49	24.46	31.08	71.86
May	12.23	25.02	32.61	71.71
June	19.00	25.59	30.46	80.00
July	18.26	24.81	31.89	81.57
Total	57.98			
Mean		24.94	31.51	76.28

3.1. Agronomic characteristics

Agronomic characteristics of peanut mulched with different thickness of rice hull and rice straw are shown in Table 2. Statistical analysis revealed that plant height (cm), leaf area index and fresh herbage yield (t ha^{-1}) were significantly affected by the different treatments. Unweeded peanut plants and those that were not mulched had the significantly tallest plant height compared to the other other treatments. This shows that peanut plants grew taller with thinner branches when exposed with high weed competition. This could be because the plants had to grow taller but thinner to be able to capture and absorb more light for its photosynthetic activities (Billen et al., 2013). Moreover, weeded and mulched peanuts regardless of the mulch thickness showed broader leaves than unweeded and unmulched peanut plants which resulted to the increase in fresh herbage yield (tha^{-1}). These results can be attributed to the early development of peanut plants when it was free from weed competition. This early development of the peanut plants resulted in bigger and broader leaves and consequently to the highest total fresh herbage yield of 5.41-6.90 t ha^{-1} regardless of the thickness of mulching materials applied. This result conforms to findings of Ahmed et al. (2014) that sweetcorn plants with less competition for growth factors had higher fresh herbage weight and total marketable yield.

Table 2. Agronomic characteristics of peanut as influenced by different thickness of rice hull and rice straw mulch.

Treatment	Number of days from planting to		Plant Height (cm)	Leaf Area Index	Fresh Herbage Yield (t ha^{-1})
	Flowering	Maturity			
T_1 = Control (unmulched and unweeded)	31.00	89.67	105.13a	3.27b	3.72b
T_2 = Hand weeded and unmulched	31.00	89.00	94.70b	4.25a	6.88a
T_3 = Rice straw (1 inch thick)	32.00	89.67	92.42b	4.56a	5.44a
T_4 = Rice hull (1 inch thick)	31.33	88.67	90.13b	4.02ab	5.94a
T_5 = Rice straw (2 inches thick)	31.33	89.33	92.35b	4.62a	6.90a
T_6 = Rice hull (2 inches thick)	30.67	89.67	89.95b	4.53a	5.41a
CV (%)	1.18	01.17	5.84	30.890	24.10

Means with the same letter in a column are not significantly different at 5% level, HSD

3.2. Yield and yield components and harvest index

Table 3 presents the yield, yield components and harvest index of peanut grown under different thickness of rice hull and rice straw mulch. Resuslt showed that number of pods per plant and fresh pod yield (t ha^{-1}) significantly differed among treatments. Peanuts mulched with rice straw at 2 inches thick produced more number of pods per plant which also resulted in the highest fresh pod yield (tha^{-1}) as compared to the unweeded and unmulched peanut plants (T_1), handweeded but not mulched (T_2), mulched with rice hull at 1 and 2 inches thick (T_4 & T_6), and with rice straw mulch at 1 inch thick (T_3). Unmulched and unweeded plants gave the lowest number of pods per plant which resulted in the lowest fresh pod yield of 1.01 tha^{-1}. This results conform to the the findings of Marasigan et al. (2015) that unweeded and unmulched mungbean plants obtained the lowest number of pods per plant and number of seeds per pod which resulted in the lowest yield (tha^{-1}) and negative net income of PhP -12.000 per hectare.

Table 3. Yield and yield components and harvest index of peanut as influenced by different thickness of rice hull and rice straw mulch.

Treatment	Number of		Wt. (g) of 1.000 seeds	Fresh pod yield (tha^{-1})	Harvest Index
	Pods $plant^{-1}$	Seed pod^{-1}			
T_1 - Control (unmulched and unweeded)	18.05c	1.70	545.33	1.01c	0.27
T_2 - Hand weeded and unmulched	23.37b	1.84	541.67	1.63b	0.24
T_3 - Rice Straw (1 inch thick)	26.03b	1.81	533.33	1.96b	0.36
T_4 - Rice hull (1 inch thick)	27.63b	1.87	533.33	1.66b	0.28
T_5 - Rice Straw (2 inches thick)	36.50a	1.90	536.67	2.64a	0.38
T_6 - Rice hull (2 inches thick)	25.83b	1.80	550.00	1.75b	0.32
CV (%)	19.05	4.77	9.01	26.13	8.53

Means with the same letter in a column are not significantly different at 5% level, HSD.

3.3. Weed parameters

Data on weeds as affected by different thickness of rice hull and rice straw mulch are presented in Table 4. Four weeks after planting (4 WAP) treatment plants significantly differed in terms of fresh and dry weights of weeds present in each plot. Hand weeded plots (T_2) were comparable to plots applied with rice straw mulch at 2 inches thick (T_5) and rice hull at 2 inches thick (T_6) in terms of fresh and dry weights of weeds. However, T_2 had significantly lower fresh and dry weights of weeds than the unweeded plots (T_1) and those mulched with rice straw and rice hull at 1 inch thick. This result could be attributed to ability of the rice straw mulch to restrict weed growth thus reducing weed population (Lassiter et al., 2016). Moreover, rice straw mulch at 2 inches thick (T_5) helped control the emergence of weeds resulting to lighter weight of fresh and dry weights of weeds at 4^{th} WAP. Jodaugiene (2016) stated that mulching rice straw effectively suppressed weed growth.

Table 4. Population, fresh and dry weight of weeds 4 weeks after planting (WAP) peanut as influenced by different thickness of rice hull and rice straw.

Treatment	Weed population (No. $plot^{-1}$)	Fresh weight of weeds (g $quadrat^{-1}$)	Dry weight of weeds (g $quadrat^{-1}$)
T_1 - Control (unmulched and unweeded)	10.00	224.00b	26.32c
T_2 - Hand weeded, no mulch	8.33	38.33a	9.15a
T_3 - Rice Straw (1- inch thick)	9.33	249.00b	17.00b
T_4 - Rice hull (1- inch thick)	8.00	253.13b	17.97b
T_5 - Rice Straw (2 - inches thick)	7.33	45.02a	10.45a
T_6 - Rice hull (2- inches thick)	8.00	98.45b	12.90b
CV (%)	26.26	22.19	25.03

Means with the same letter in a column are not significantly different at 5% level, HSD.

The dominant weed species observed in unweeded plots and plots applied with rice hull mulch were purple nutsedge (*Cyperus rotundus* L.), goat weed (*Ageratum conyzoides* L.), pig weed (*Portulaca oleracea* L.), touch-me-not (*Mimosa pudica* L.), kudzu (*Centrosema pubescens*), ginger grass (*Paspalum distichum* L.), and itch grass (*Rottboellia cochinchinensis*) (Mahoney et al., 2019). The bulkiness of rice straw and rice hull as mulch at 2 inches thick effectively covered the soil surface in between peanut plants which resulted to low fresh and dry weights of weeds. This conforms with the findings of Lassiter et al., (2016) that rice straw as mulch effectively

suppressed weeds more than rice hull. They reported that rice straw reduced weed growth even during the fallow period.

3.4. Soil chemical properties

Table 5 shows the results of soil analysis before planting and after harvest of peanut. Soil analysis shows that the experimental area had a pH of 5.38, 1.83% organic matter, 0.13% total N, 13.29 mg kg^{-1} available P, and 0.68 me 100 g^{-1} exchangeable K. The results indicated that the experimental area is strongly acidic with very low organic matter, low N, high amount of available P and exchangeable K (Landon, 1991).

Table 5. Results of soil chemical analyses before planting and after harvest of peanut as influenced by thickness of rice hull and rice straw mulch.

Treatment	Soil pH (1:2.5)	Organic matter (%)	Total N (%)	Available P (mg kg^{-1})	Exchangeable K (me100 g^{-1})
Initial Analysis	5.38	1.83	0.13	13.29	0.68
Final Analysis					
T_1- Control (unmulched and unweeded)	5.45	1.38	0.13	12.98	0.60
T_2 - Hand weeded and unmulched	6.27	1.33	0.14	17.29	0.65
T_3 - Rice straw (1 inch thick)	6.03	1.39	0.13	17.29	0.54
T_4 - Rice hull (1 inch thick)	6.29	1.38	0.13	14.03	0.57
T_5 - Rice straw (2 inches thick)	6.14	1.39	0.13	15.00	0.60
T_6 - Rice hull (2 inches thick)	6.17	1.39	0.13	19.49	0.63

Final soil analysis showed a slight decrease in % OM and exchangeable K due to low mineralization and crop utilization. However, there was slight increase in pH and available P except on T_1-control (unmulch and unweeded) plots. The slight increase in soil pH and available P could be due to the high amount of decomposed mulching materials. Akter et al., (2017) stated that mulching materials contain numerous elements essential for plant growth and development.

3.5. Cost and gross margin analysis

The gross margin analysis of peanut production per hectare grown under different thickness of rice-based mulching materials as weed control is presented in Table 6. Highest net margin of PhP 88,701.00 ha^{-1} was obtained in T_5 (rice straw mulch at 2 inches thick). The result was due to higher pod yield produced. This was followed by plants mulched with 1 inch thick rice straw (T_3) with PhP 62,851.00 ha^{-1}. Lowest gross income of PhP 27,251.00 ha^{-1} was obtained in T_1 due to lower pod yield produced per hectare.

Table 6. Gross margin analysis of peanut as influenced by different thickness of rice hull and straw mulch.

Treatment	Fresh pod Yield (t ha^{-1})	Gross Income (PhP)	Total Variable Cost (PhP)	Gross margin (PhP)
T_1 - Control (unmulched and unweeded)	1.01c	50,500.00	23,249.84	27,251.00
T_2 - Hand weeded and no mulched	1.63b	81,500.00	33,249.84	48,251.00
T_3 - Rice straw (1 inch thick)	1.96b	98,000.00	35,149.84	62,851.00
T_4 - Rice hull (1 inch thick)	1.66b	83,000.00	34,499.84	48,501.00
T_5 - Rice straw (2 inches thick)	2.64a	132,000.00	43,299.84	88,701.00
T_6 - Rice hull (2 inches thick)	1.75b	87,500.00	41,999.84	45,501.00

Calculation of gross income based on the current market price of peanut @ PhP 50 kg^{-1}

4. Conclusion and Recommendation

Based on the results of the study, it can be concluded that utilization of rice wastes as organic mulching materials significantly improved the plant height (cm) and leaf area index as well as the number of pods per plant and fresh yield (tha^{-1}) of peanut. Rice straw mulch at 2 inches thick was considered the best treatment since it was able to effectively control the growth of weeds similar to the hand weeded plots. Peanut plants mulched with rice straw at 2 inches thick were also able to produce the highest pod yield of 2.64 tha^{-1}, and the highest gross margin of PhP 88,701.00 ha^{-1}.

Based on gross margin analysis, the application of rice straw mulch at 2 inches thick is recommended for peanut production to control weeds. It is recommended further that similar study be conducted under different agro-climatic conditions to verify further the results of this study.

Conflicts of Interests

Authors declare that there is no conflict of interests

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