# Mulching Materials as Yield Booster for Sustainable Mungbean Production

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**Abstract – The effect of different mulching materials on mungbean production was studied. The general objective was to assess the ecological effects of mulching materials in sustainable mungbean production. Specifically, the study aimed to determine the effects of different mulching materials on the chemical, physical and biological soil properties, on weed control and yield, and to identify mulching materials that are environmentally friendly in mungbean production. The experiment was conducted at the Fruit and Vegetables Seeds Center, Science City of Muñoz, Nueva Ecija, Philippines from May to July 2004. The initial soil chemical properties were: pH of 6.4, 2.0 percent organic matter content, 0.10 percent total nitrogen, 22 ppm phosphorus, and 370 ppm available potassium. The soil microbial loads were $8 \times 10^4$ CFU $g^{-1}$ for bacteria and $14 \times 10^4$ CFU $g^{-1}$ for fungi. Mushroom spent mulch increased soil organic matter with an average of 3.13 percent, nitrogen with an average of 0.16 percent and the highest number of bacterial count with $3.4 \times 10^8$ CFU $g^{-1}$. Use of mulch, except rice straw mulch, generally increased mungbean yield. The best mulching material for high yield production of mungbean was black polyethylene plastic film, although environmentally unfriendly.**

**Key words : Sustainable production, mulching, mungbean**

## INTRODUCTION

The main concerns of the agricultural sector are farm productivity, economic return and resource sustainability. Mungbean (*Vigna radiata* L.), an important short duration grain legume in Asia, is one of the traditional annual crops grown in Korea. It contains 20 to 25 percent proteins, 48 to 63 percent carbohydrates, andsmaller proportinons of vitamins and minerals. Mungbean is a remarkably adaptable crop (Zangh *et al.* 2003), it has low input requirements and has the ability to restore soil fertility through symbiotic nitrogen fixation (Firth *et al.* 1973).

However, farmers are distressed with numerous problems such as weed growth, pests and diseases, declining soil fertility and water stress. In response to these problems farmers have resorted to agricultural chemicals to control pests and diseases and weeds. They also use non-biodegradable mulching materials like polyethylene plastic to regulate moisture and weeds.

Soil and water contaminations by the use of agricultural chemicals, such as herbicides and fertilizers, have drawn public alarm since these may pollute agricultural lands as well as the food products grown on these lands. As a method to reduce the use of agricultural chemicals, mulching with thin plastic film has been commonly practiced for many years. Although this is very effective in preventing the growth of weeds, it is almost impossible to remove all of the plastic film from the field, and the remaining film eventually contaminates the soils (Seoul National University 2000).

Sustainable agriculture represents a positive response to the limits and problems of both traditional and modern agriculture. One of the practices in sustainable agriculture

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is mulching with biodegradable materials. It protects the topsoil, conserves moisture, and reduces weed growth. The mulch tends to be an insulator, moderating the temperature of the soil beneath (Johns 1979). However, the main objectives of mulching are to improve and maintain the productivity of the soil and to protect the soil against adverse environmental factors.

Considering the above problems and concerns, this study was therefore conducted from May to July 2004 to assess the ecological and economic effects of mulching materials in sustainable mungbean production. Specifically, the study aimed to a) evaluate the effect of the different mulching materials on soil physical, chemical and biological properties; b) compare the effects of the different mulching materials on mungbean production; c) identify the best mulching material for high yield production of mungbean.

## MATERIALS AND METHODS

The experimental site was located at the Fruit and Vegetables Seed Center, Science City of Muoz, Nueva Ecija. The soil in the area belongs to the Maligaya series with a textural class of Maligaya clay, with water holding capacity of 57.17 percent, field capacity of 28.34 percent and found to be poorly drained (Mactal 1998).

Soil samples were taken from the experimental area before and after the experiment to determine the chemical and biological properties of the soil, like organic matter, pH and microbial load. Sampling was carried out every week after planting for the physical analysis. Composite soil samples were taken for physical and chemical property analysis. The soil samples were air-dried (except for microbial population analysis), pulverized and passed through a 2.0 mm sieve.

The Standard Plate Count Method was used for the analysis of soil microbial load, the modified Kjedahl method for nitrogen content, Flame Photometer Method for potassium content, Olsen's Method for phosphorus content, pH meter for pH, and Wilde's Method for soil organic matter content (Kim 2004).

Data on agro-climactic conditions during the study, such as sunshine duration and rainfall, were taken from the PAGASA station of the Central Luzon State University.

An area of 195.5 $m^2$ was used in the study. The experimental area was irrigated, then prepared by alternate plowing and harrowing using a tractor until a good soil tilth was attained. The area was laid out following the Randomized Complete Block Design (RCBD) with four replications. The plot was divided into four blocks with 1 m distance between blocks. Each block was divided into six plots representing the treatments with dimension of 15 m, and 0.5 m distance between plots. Plots were elevated approximately 30 cm.

Different mulching materials were applied to each plot following the treatments assigned. Two cm thick of the different mulching materials (T3 to T6) were hand pressed to the ground for better lay outing.

Mungbean (NSIC Mg11) seeds were planted at a distance of 50 cm between row and 10 cm between hills at the rate of three seeds per hill. Complete fertilizer (14-14-14) was applied uniformly by band method at the rate of 30-30-30 kg NPK per hectare. Overhead irrigation was done after planting and thereafter whenever the plants exhibited signs of wilting.

| Treatment | Description |
|---|---|
| T1 | No mulch (control) |
| T2 | Black polyethylene plastic film (control) |
| T3 | Acacia sawdust |
| T4 | Rice straw |
| T5 | Rice hull |
| T6 | *Pleurotus* mushroom spent (partially decomposed rice straw) |

To minimize weed infestation, hand-weeding was done every week. Botanical fungicide from garlic (*Allium sativum* L.) extract was used to control fungi in the plants. Botanical pesticide from Neem tree (*Azadirachta indica* A. Juss) extract was used to control pests and diseases. Vinegarwas applied as botanical pesticide to control red fire ants during the seedling stage.

## RESULTS AND DISCUSSION

### 1. Chemical and biological soil properties

Soil pH decreased to a range of 6.05 in the no mulch treatment to 6.25 in the acacia sawdust mulch. The lowest soil pH after the experiment was observed in the no mulch treatment as well as in the black polyethylene plastic mulch (6.08). Decrease in pH in the no mulch treatment was significantly lower than the other treatments. Although the weeds under black polyethylene plastic film mulch may have died and decomposed under low oxygen/high moisture conditions which resulted in the decline in pH, the resulting pH was not significantly different from those by the other mulch treatments. Williams (1997) said that organic mulches raise the pH slightly, making the soil more alkaline. Hansen and May (1997) said that properly composted organic material has a pH of 6.0 to 7.2 although they pointed out that the pH of the mulch usually does not cause a significant change in soil pH around plant roots. Oplinger *et al.* (1997) noted that mungbean requires slightly acid soil for best growth and performs best on soils with a pH between 6.2 and 7.2.

Organic matter content of the soil after the experiment decreased in all treatments except that under the mushroom spent mulch (3.125 percent), which was significantly higher than all the other treatments. Plant materials such as rice straw, rice hull, leaf, or sawdust used as mulch decompose and serve as a source of organic matter (Skelly 2002). However, in this study using acacia sawdust, rice straw and rice hull for mulch significantly reduced soil organic matter as compared to the mushroom spent mulch. This observation was unexpected since sawdust and straw used as mulch can rapidly decompose and become part of the soil (Skelly 2002), which should have resulted in an increase in soil organic matter in these treatments. On the contrary, the acacia sawdust and rice straw were still identifiable at the end of experiment such that they were scrapped off the soil surface when the soil sample was taken for analysis. One reason could be that hay does not form a mat, but remains rigid and loose (University of Illinois Extension 2003), while the sawdust was not properly aerated. These could have hampered decomposition of the rice straw and acacia sawdust. Rice hull, on the other hand, has a high lignin content which makes it difficult to decompose.

While the mushroom spent mulch was initially of rice straw, it has already undergone initial decomposition when it was used to raise mushrooms. Cohen *et al.* (2002) noted that one of the most important aspects of *Pleurotus* spp is the use of their ligninolytic system for the bioconversion of agricultural wastes into valuable products for animal feed and other food products, and the use of their ligninolytic enzymes for the biodegradation of organo-pollutants, xenobiotics and industrial contaminants. As a biotechnological process to recycle ligninocellulosic wastes (Sanchez 2004), use of the rice straw for mushroom culture accelerated the decomposition of the mulch and consequently facilitated its conversion into soil organic matter.

Soil nitrogen content decreased in all treatments except in the mushroom spent mulch where it increased to 0.16 percent. Phosphorus content decreased to a range of 12.83 ppm in the rice hull mulch to 22.50 ppm in the no mulch treatment, and increased to 22.25 ppm in the mushroom spent and no mulch treatments. Potassium content decreased to a range of 345 ppm under acacia sawdust mulch to 245 ppm in the no mulch treatment, with significant differences among the different treatments.

Organic mulches of plant origin add small amounts of nutrients to the soil through decomposition, although these have little effect on the nutrient level in the soil and should not be considered a substitute for fertilizer (Williams 1997). Hayden (n.d.) noted that some types of mulch, such as sawdust, decompose very slowly, and the microorganisms which decompose the mulch may rob the soil of available nitrogen during the early period of decomposition. As the sawdust starts decomposing soil bacteria may tie-up or "borrow temporarily" some available nitrogen, and may cause plants to appear stunted and yellowish (University of Illinois Extension 2003), but as the sawdust finishes decomposing, nitrogen will be returned to the soil. Williams (1997) also noted that even if quickly decaying organic mulches, such as fresh leaves, wood chips and straw, are used, a considerable amount of nitrogen is taken from the soil by the microorganisms decomposing organic matters, thus reducing nitrogen reserves in the root zone of the growing plant. On the other hand, Xu *et al.* (2004) reported that nitrous oxide ($N_2O$) emissions from unsaturated rice fields covered with plastic or straw mulch were large and varied considerably during the rice season. Stewart *et al.* (2000) found that only 3 percent of potassium (14 kg $ha^{-1}$) provided by spent mushroom compost is lost by leaching; hence, it could provide plants with potassium, among others.

The bacterial load of the soil increased to a range of 1.91 $\times 10^6$ CFU $g^{-1}$ under the polyethylene plastic mulch to 3.42 $\times 10^6$ CFU $g^{-1}$ under mushroom spent mulch, although there were no significant differences among treatment means. Bacterial counts after the experiment were statisti-

**Table 1.** Chemical and biological soil properties of experiment area

| Parameter | Before experiment | After experiment | | | | | |
|---|---|---|---|---|---|---|---|
| | | No mulch | Black polyethylene plastic film | Acacia sawdust | Rice straw | Rice hull | *Pleurotus* mushroom spent |
| Chemical properties | | | | | | | |
| pH | 6.40 | 6.05 | 6.08 | 6.25 | 6.20 | 6.10 | 6.23 |
| OM (%) | 2.01 | 1.75$^b$ | 1.50$^b$ | 1.63$^b$ | 1.50$^b$ | 1.50$^b$ | 3.13$^a$ |
| Total N (%) | 0.10 | 0.09$^b$ | 0.07$^b$ | 0.08$^b$ | 0.07$^b$ | 0.07$^b$ | 0.16$^a$ |
| P (ppm) | 22.03 | 22.50$^a$ | 14.25$^b$ | 13.25$^b$ | 14.83$^b$ | 12.83$^b$ | 22.25$^a$ |
| K (ppm) | 370.00 | 245.00$^d$ | 280.00$^c$ | 345.00$^a$ | 307.50$^{ab}$ | 285.00$^c$ | 305.00$^{bc}$ |
| Biological properties | | | | | | | |
| Bacterial count (CFU $g^{-1}$) | $8.01 \times 10^4$ | $2.25 \times 10^6$ | $1.92 \times 10^6$ | $2.10 \times 10^6$ | $3.00 \times 10^6$ | $2.06 \times 10^6$ | $3.42 \times 10^6$ |
| Fungal count (CFU $g^{-1}$) | $1.43 \times 10^5$ | $2.55 \times 10^4$ | $4.54 \times 10^4$ | $4.19 \times 10^4$** | $2.99 \times 10^4$ | $2.99 \times 10^4$ | $2.61 \times 10^4$ |
| Physical properties | | | | | | | |
| Soil moisture content (%) | | 26.78$^b$ | 26.83$^b$ | 30.08$^a$ | 28.18$^{ab}$ | 26.10$^b$ | 26.45$^b$ |

In each row, means followed by common letter are not significantly different at 5 percent level by LSD.

cally greater than those before the experiment. The higher bacterial count in the organic mulch treatments, compared to the plastic mulch, is consistent with the notion that organic mulches serve as food for many microorganisms in the soil, some of which are necessary for maintaining and promoting soil granulation (Williams 1997). That the bacterial count in the no mulch treatment was higher suggests that food for the microorganisms was more readily available under this treatment than the rice hull or acacia sawdust mulch. Bacteria present under the different treatments were not bacteriologically differentiated.

Soil fungal count significantly decreased in all the treatments after the experiment. Combined with the bacterial count data, this indicates that the experimental area was generally well drained since molds often develop on organic mulches if they are kept too wet (Williams 1997).

Soil moisture content under the acacia sawdust mulch was higher but not significantly different from that under rice straw; it was significantly higher than in all the other mulch treatments and the control.

## 2. Yield and yield components

### 1) Number of filled and unfilled pods

The number of filled pods ranged from 14.52 to 21.20 in the no mulch and rice hull mulch, respectively. Results indicated that mulching significantly increased filled pods in mungbean. Rice hull and *Pleurotus* mushroom spent (19.38) mulch significantly increased the number of filled pods over the control. Other mulching materials were comparable with each other, including the control.

The number of unfilled pods from the different treatments registered no significant differences. Treatments with more filled pods likewise produced more unfilled pods as in the rice hull and *Pleurotus* mushroom spent mulch. These treatments produced an average of 4.0 unfilled pods.

Surin (2003) mentioned that number of pods per plant may be influenced by the environmental conditions during the pod filling and maturity stage. Typhoon was observed during the pod filling stage which may have slowed down photosynthesis and respiration and affected the total number of pods per plant produced.

### 2) Shelling percentage

The shelling percentage of mungbean pods ranged from 53.34 to 61.54 in the acacia sawdust and rice hull mulch treatment, respectively. It is interesting to note, however, that control plants tended to have a higher shelling percentage than plants mulched with acacia sawdust and *Pleurotus* mushroom spent. On the other hand, there were no significant differences among treatment means.

### 3) 1000 seed weight

The weight of 1000 seeds did not vary significantly among the different mulch treatments. Control plants (55.25 g) produced seeds with comparable weight to the different mulching materials. Seeds from the polyethylene plastic film mulch (59.25 g) were bigger than those produced from other mulching materials and the control. This observation agrees with that of Tobias (1996) that plants mulched with

**Table 2.** Yield and yield component of mungbean

| Treatment | Filled pods (No.) | Unfilled pots (No.) | Shelling percentage (%) | 1000 Seeds weight (g) | Seed yield (kg) | Harbage yield (g) |
|---|---|---|---|---|---|---|
| No mulch | 14.52[c] | 3.40 | 61.25 | 55.25 | 949.00[c] | 37.82[c] |
| Black polyethylene plastic film | 18.05[abc] | 3.65 | 57.75 | 59.25 | 1317.00[a] | 40.25[bc] |
| Acacia sawdust | 17.05[bc] | 2.55 | 56.34 | 55.50 | 1118.50[b] | 37.98[c] |
| Rice straw | 17.80[abc] | 3.98 | 60.74 | 53.75 | 910.50[c] | 46.40[a] |
| Rice hull | 21.20[a] | 4.18 | 61.54 | 54.00 | 1124.50[b] | 47.92[a] |
| *Pleurotus* mushroom spent | 19.38[ab] | 4.08 | 57.00 | 55.75 | 1232.00[ab] | 44.10[ab] |

In each row, means followed by common letter are not significantly different at 5 percent level by LSD.

white polyethylene mulch positively affected seed size and weight with the heaviest was from the mulched plants.

4) Seed yield

The use of mulch, in general, significantly increased seed yield of mungbean. Control plants registered significantly lower seed yield (910.50 kg $ha^{-1}$) compared to those in the different mulch treatments, except rice straw mulch (910.50 kg $ha^{-1}$), which was lower than control. This observation is contrary to previous reports. The AVRDC (2003) reported that mungbean (SML668) produced significantly higher yield under straw mulch (2,301 kg $ha^{-1}$) compared to no mulch (2,012 kg $ha^{-1}$). Ramakrishna, *et al.* (2002) also reported that straw mulch increased ground-nut yield by 71 percent over the no mulch treatment. Likewise, Ochasan (1980) reported that Chinese cabbage mulched with rice straw had the highest total yield per plot (22.23 kg) compared to sawdust mulch (21.28 kg) and no mulch treatments (15.17 kg). The present observation also runscounter to recommendations of PCARRD (n.d.) to apply rice straw mulch to mungbean immediately after planting, and the Xavier University Periurban Vegetable Project (Holmer 2000) to use rice straw for mulch.

Black polyethylene plastic film mulch produced the highest seed yield (1317.00 kg $ha^{-1}$) which was significantly higher than that of the rice straw, acacia sawdust, (1118.50 kg $ha^{-1}$), rice hull (1124.50 kg $ha^{-1}$) and the no mulch treatments, but not significantly different from that of the mushroom spent (1232.00 kg $ha^{-1}$) mulch. This result is contrary to the recommendation of the Xavier University Periurban Vegetable Project (Holmer 2000) not to use black plastic mulch because it heats up too much and can burn stems and other plant parts, which can reduce yield.

The generally significantly higher number of filled pods ultimately contributed to higher seed yield.

5) Herbage yield

Herbage yield of mungbean ranged from 37.82 to 47.92 g $plant^{-1}$ in the no mulch and rice hull mulch, respectively. This indicates that herbage yield increased in all the mulch treatments. There were significant differences in herbage yield of mungbean. The no mulch treatment produced significantly less herbage than all the mulch treatments, except acacia sawdust. Among the different mulch treatments rice hull (47.92 g), rice straw (46.40 g) and mushroom spent (44.10 g) were not significantly different from each other. Both rice hull and rice straw mulches produced significantly more herbage than black polyethylene plastic film (40.25 g $plant^{-1}$), acacia sawdust (37.98 g $ha^{-1}$) and no mulch treatment. The mushroom spent mulch was significantly higher than the sawdust and no mulch treatments. No other significant differences were observed.

## CONCLUSIONS

The experiment was conducted to assess the ecological and economical effects of mulching materials on sustainable mungbean production.

Soil pH slightly decreased from 6.4 to a range of 6.05 to 6.25. Organic matter, decreased in all treatments except for mushroom spent mulch. Total nitrogen content decreased from 0.10 to a range of 0.07 to 0.09 for all mulch treatments except mushroom spent mulch where it increased to 0.16 percent. Phosphorusand potassium generally decreased after the experiment except in the no mulch and mushroom spent treatment where phosphorus increased.

Soil moisture was affected substantially by the mulching treatments and the weather condition. Acacia sawdust had the highest moisture content during the experiment which ranged from 27.25 to 36.92.

Bacterial count increased significantly from the initial count while the fungal count decreased.

The kind of mulch used had significantly different effects on mungbean production. Useof mulch generally increased mungbean yield except rice straw mulch. The best mulching materials for high yield production of mungbean was black polyethylene plastic film mulch, but it was not statistically different from mushroom spent mulch.

Considering the results of the study, the following conclusions can be made: Mulching generally improved soil physical, chemical and biological properties by increasing soil moisture content, maintaining soil pH and potassium level, and modifying bacterial and fungal contents favorable to mungbean production.

Mulching generally increased mungbean production in terms of seed and herbage yield.

The best mulching materials in attaining high yield in mungbean production are black polyethylene plastic film, *Pleurotus* mushroom spent, rice hull and acacia sawdust, in this order.

### Recommendation

The followings are recommended in the light of the results of this study: Farmers should use farm wastes mushroom spent, rice hull and acacia sawdust as affordable mulching materials for mungbean production at the rate of 50 t $ha^{-1}$.

The results obtained from the rice straw mulch contradicts previous reports which favorably promote rice straw as a mulching material. Result of this study indicates that it should be subjected to further tests as a mulching material for mungbean.

Since mungbean is usually a dry season or dry land crop, and the plots in this study were subjected to intermittent flooding due to typhoons and the early monsoon rains, a similar study should be conducted in an environment more favorable to mungbean production.

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