Science and Technology Journal
Vol. VIII 2018 Issue
ISSN: 2012 0060

MULCHING AS A CONTROL STRATEGY FOR THE MAJOR PESTS OF TOMATO (*Solanum lycopersicum* L.*)* DURING THE WET SEASON

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ABSTRACT

Field experiments, to evaluate the effects of different mulching materials on the control of major pests and yield performance of tomato, were conducted at the MMSU, Experimental Farm, City of Batac during the wet season (WS) from 2012 to 2015. The following mulching materials were used as experimental treatments: plastic mulch (PM), rice straw (RS), dried grasses (DG), rice hull (RH), carbonized rice hull (CRH) and sawdust (SD). Unmulched treatment was included as the negative control.

Mulching materials such as RS and DG were effective as PM in controlling weeds. The common insect pests observed during the study period were fruitworm, leaf curling and leaf blight. The use of these mulching materials minimizes pest infestation and weed growth.

The marketable yield of tomato mulched with PM, DG and RS per hectare significantly obtained the highest during the four wet season trials. The lowest yield was significantly observed from the UM, SD, CRH and RH. In addition, the net return was highest with the use of PM at ₱390,350 with an average yield of 27.18 tha^{-1}, followed by using DG and RS. Hence, these two mulching materials such as RS and DG could be a good substitute for PM, which is costly. These are locally available and using these materials could provide a farmer a very good return.

Keywords: *Wet season tomato production, tomato pests, Integrated pest management, mulching materials*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.*)* belongs to the family *Solanaceae* and plays an important role in human diet. It is a valuable source of vitamins A and C, as well as several minerals including calcium, iron, manganese, and particularly potassium (Kaur and Kapoor, 2008). It also contains lycopene, which is a carotenoid (a pigment involved in photosynthesis) that gives red coloring to tomatoes (Kelley and Boyhan, 2010), as cited by Tegen *et al.*, 2016).

Tomato production during the wet season (WS) is very profitable. The price of tomato is very high and marketing is not a problem. However, there is high pest infestation during this period which adversely affect fruit yield although even in tomato varieties recommended for WS planting. Mulching positively influences crop growth and yield by balancing soil humidity, temperature and structure (Janina von Diest and Pia Addison, 2016).

In the Philippines, particularly in the Ilocos province, one of the present cultural practices of the farmers for the control of pest is the use of chemical pesticides which lead to pest outbreak or resurgence, and is aggravating insect pest and disease

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problems in producing vegetables (LA Lutap and MI Atis, 2013). Insect pests and diseases of tomato are managed by using chemical, biological, and remedial measures. Most of the pests and diseases such as fruitworm, leaf blight and leaf curling of tomato are common throughout the year, except thrips and whiteflies, which are present only during dry season starting in January, declining in May and ending in June or July depending on the arrival of rain (https://www.bar.gov.ph/index.php/agfishtech-home/crops/207-vegetables/1304-tomato-con-t).

Hence, to provide a suitable environment for tomato crop in which increased yields of high quality produce can be grown, mulching materials has been used for wet season tomato production. This type of crop cultivation, by protecting crops against environmental stresses, can result in stable yields of high quality produce, which sells at a good price.

Mulching is the process of covering the soil/ground to make more favorable for plant growth. (Dalorima L.T. 2014). It minimizes soil erosion and compaction from heavy rains, limits growth of weeds near plants, and indigenous mulch that is derived from plant material will decompose (Nisnisan, 2014). According to Acayen, Mandaraog, Mariano and Rivero, (2005), indigenous mulches also help enriched the soil with nutrients as they breakdown.

According to Bhardwaj (2013), mulching reduces the germination and nourishment of many weeds. The mulching operation favors in the reduction of weed seed germination, weeds growth and keeps the weed under control. In covering or mulching the soil surface can prevent weed seed germination or physically suppress seedling emergence, thus provide effective weed control.

Mulch suppresses weed growth, reduces soil erosion and prevent fruits from touching the soil and eventual rotting. Common observations also indicate that it reduces leaf and fruit diseases during the rainy season. Thus, mulch could ensure good crop yield, economize fertilizer and water use and sustain crop productivity for years without depleting the soil.

According to Kayum 2008, different types of mulch save labor cost for weed control and improves soil physical conditions by enhancing biological activity of soil fauna and thus increases soil fertility which ultimately increases the yield of tomato.

One of the most anticipated effects of mulching in tomato production is on pest control. Hence, this study was undertaken to evaluate and identify the best mulching materials on the control of major pests that could increase the yield and profit of tomato farmers during the WS.

METHODOLOGY

Locale of the Study

The trial was conducted at the experimental farm of the Mariano Marcos State University (MMSU), City of Batac, Ilocos Norte. Based on the Corona classification, the climate of Ilocos Norte belongs to Type 1, i.e., two distinct seasons, wet and dry. Wet season is from May to October. About 90% of the total annual rainfall, averaging 2000mm, occurred within this period. An average of six tropical cyclones visited the area each year, most of which are considered tropical storms (62-117 kph), and typhoons (118-239kph). These tropical cyclones brought heavy rains that usually keep the low-lying areas submerged or waterlogged; and which such conditions do not favor the cultivation of tomato. The application of improved cultural management technique, such as the use of appropriate mulching materials can be one factor that could provide better environment for the test plants during the WS.

Experimental design and treatments

The experiment was laid-out in a Randomized Complete Block Design (RCBD) with three replications. The treatments were as follows: T_1 - Plastic Mulch (PM); T_2 - Dried Grasses (DG); T_3 - Rice Straw (RS); T_4 - Unmulched (UM) (control); T_5 - Sawdust (SD); T_6 - Carbonized Rice Hull (CRH) and T_7 - Rice Hull (RH).

Cultural Management

Recommended cultural management practices based on evaluation trial was strictly followed. A seedbed was prepared and seeds were sown thinly in rows spaced at 5cm, then covered with soil mixture. Daily watering was done in the morning or late in the afternoon. One week before transplanting, the seedlings were hardened by gradually reducing the frequency of watering. Thorough land preparation was employed wherein plowing and harrowing were done alternatively two times. Mulching materials and organic fertilizer were placed before transplanting. Seedlings were transplanted in raised beds three to four weeks after sowing. Raised beds were prepared at 20cm high; width of plots was 1.0m, double row plots were used, 5m long and 0.4m distance between hills. Basal application of 14-14-14 during transplanting was done at the rate of 15g $hill^{-1}$. The first side-dressing was applied three weeks after transplanting (WAT) by mixing two parts urea (46-0-0) and one part muriate of potash (0-0-60). This mixture was applied at the rate of 10g (1tsp) $hill^{-1}$, 6-8cm away from the base of the seedlings. The same mixture was side-dressed two weeks later. Supplemental irrigation was given as the need arises.

Data gathering procedures

Data on the prevalence of pests were gathered 8 WAT. The different weed species were identified, monitored and gathered by using one quadrant sampling per treatment. Persistent weed species in each treatment were identified, oven-dried and weighed. Data on the incidence of insect pests and diseases were gathered based on % infestation and % infection.

Time needed in weeding each treatment was recorded and this was used as basis in the computation of the cost and return analysis. Other data gathered were percent survival, days to first flower, days to maturity which was taken on the number of days to first and last harvestings, plant height at maturity, yield and yield components, cost and return analysis.

The gathered data were analyzed using the Analysis of Variance for RCBD. Treatment means of parameters that showed significant F-test results were further compared using HSD at 5% level of significance.

RESULTS AND DISCUSSION

Effect of mulch on pest incidence

Weed identity and density

The identified weed species in the experimental plots mulched with different mulching materials taken at early fruiting stage of the plants during the WS 2012 to WS 2015 were *Cyperus rotundos* L., *Cynodon dactylon* (L.) Pers, *Chrisopogan aciculatus* (Retz), *Brachiaria mutica* (Forssk), *Amaranthus spinosus* L., *Desmanthus virgalus* L., *Imperata cylindrica* L. (Beau V.), *Corchorus capsularis* L. and *Spanacia oleracea* L.

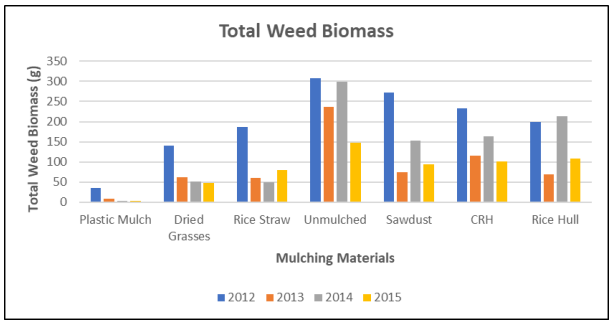

Fig. 1. Total weed biomass in tomato plots mulched with different kinds of mulching materials

Significant interaction effect was also obtained on tomato plants mulched with different kinds of mulching materials planted for four years (Fig. 1). The lowest weed biomass was taken from plots mulched with plastic sheet during the WS 2012-2015 with 36.2g, 9.1g, 4.3g and 3.0g, respectively. This was followed by DG and RS during the WS 2013 to WS 2015 with 47.2g to 80.2g weed biomass. The highest weed biomass was observed from unmulched plots during the WS 2012 to WS 2014 at 308.1g, 236.9g and 299.6g, respectively; followed by the use of SD, CRH and RH.

It was observed that there was higher weed biomass in plots mulched with SD, CRH, and RH especially during heavy rains which easily washed-up these materials.

Vegetable producers have used plastic mulches for at least 40 years to prevent weed growth near the crop, and promote crop yields. Easy mechanical application, cost efficient weed control, and increased crop yields have led to widespread adoption of plastic mulch by organic and conventional vegetable farmers (Schonbeck, 2012). Valipour M., *et al.* (2020) stated that mulches suppress the weeds in crop plants, and remove the residual effects of pesticides, fertilizers, and heavy metals. The selection of mulching material is important with respect to crop type, management practices, and climatic conditions. The appropriate mulching technique could provide the aforementioned benefits to the agro-ecological systems.

According to Babatunde and Etukudo (2015), as cited by Uguajio and Ernest 2014, polyethylene mulches are widely used in vegetable production and have contributed significantly to reduction of losses due to weed competition.

Table 1. Pests in tomato planted with different mulching materials during the WS 2012 to WS 2015

TREATMENTS	TOTAL WEED BIOMASS (g/quadrant)	FRUITWORM DAMAGE (%)	LEAF CURLING DAMAGE (%)	LEAF BLIGHT DAMAGE (%)
Mulching Materials MM)	**	*	**	**
1. Dried Grasses	75.11d	21.11a	26.45b	17.02de
2. Rice Straw	94.87cd	20.45a	18.74e	11.43e
3 Sawdust	147.18bc	22.68a	28.30abcd	27.62cd
4. CRH	149.02b	21.06a	24.98cd	20.35d
5. Rice Hull	153.44b	19.25b	28.36abc	35.48ab
6. Plastic Mulch (ck)	13.21e	21.28a	28.94ab	29.94c
7. Unmulched (ck)	248.26a	22.00a	30.57a	39.25a
Year (Y)	**	**	**	**
2012	196.62a	29.52a	32.83a	28.98ab
2013	89.77c	24.07b	32.15ab	31.50a
2014	133.67b	14.25c	20.68c	20.57c
2015	83.29c	16.63c	20.81c	22.43c
MM:Y	**	**	**	**
CV (%)	5.79	7.57	5.64	7.80

** - significant at 1% level
* - significant at 5% level
In a column, means marked with the same letter are not significantly different using HSD.

In a study done by Gomonet and Cagasan (2020) stated that mulching material such as rice straw, control weeds and enhance the growth and yield of the crop. In another study conducted by Abouziena H. F. and S.M. Radwan (2015), they stated that organic mulch are effective for weed control and could be a potential alternative to synthetic herbicides, hoeing or hand removal of weeds in onion organic farming.

Insect pests

Table 1 also shows the mean data on pests infestation/infection of tomato plants mulched with different kinds of mulching materials, analyzed across years during the WS 2012 to WS 2015. The common pests observed were fruitworm, leaf curling and leaf blight, wherein significant variations were obtained.

There was a significant interaction effect on the tomato plants mulched with mulching materials planted in four years (Fig. 2). The lowest fruitworm infestations were obtained during the WS 2014 (11.52% to 16.64%) and 2015 (9.99% to 18.76%). The highest fruitworm infestation was observed during the WS 2012 and 2013 in all plants mulched with the different mulching materials. This might be attributed to the high amount of rainfall and low bright sunshine which favored fruit worm infestation (Fig. 5 and 6).

Significant interaction effect was also obtained on the percent leaf curling infection of tomato plants mulched with different kinds of mulching materials planted in four years (Fig. 3). The lowest leaf curl infection was observed from plants mulched with plastic sheet during the WS 2013, 2014 and 2015 with an infection of 15.65%, 16.00% and 17.25%, respectively. This was followed by plants mulched with dried grasses (17.00%) and rice straw (18.62%). Highest infection was observed during the WS 2012 and WS 2013 in plants without mulch at 36.75% and 36.92%, respectively. The occurrence of typhoon during the year 2012 and 2013

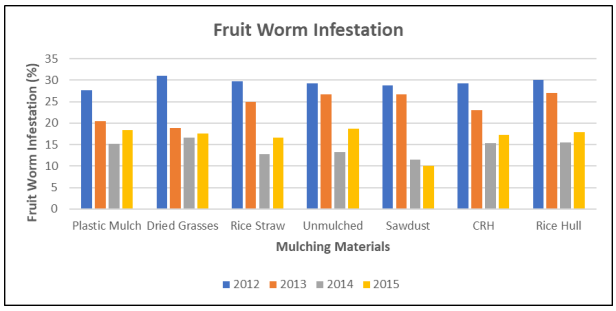

Fig. 2. Fruitworm infestation of tomato plants mulched with different kinds of mulching materials

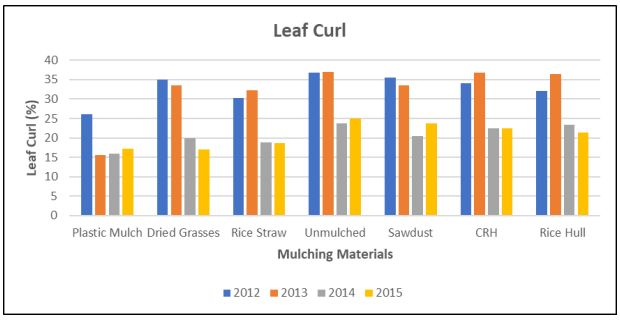

Fig. 3. Leaf curling of tomato plants mulched with different kinds of mulching materials

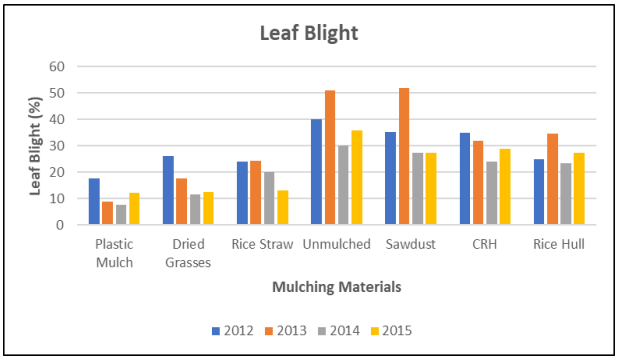

Fig. 4. Leaf blight of tomato plants mulched with different kinds of mulching materials

contributed to the high amount of rainfall in the month of August with 956.3mm and 1006.5mm rainfall (Fig. 5); this condition made the plants susceptible to leaf curling infection.

Significant interaction effect was noticed on the percent leaf blight infection of the tomato plants with different kinds of mulching materials planted in four years (Fig. 4). Plants with plastic mulch had the

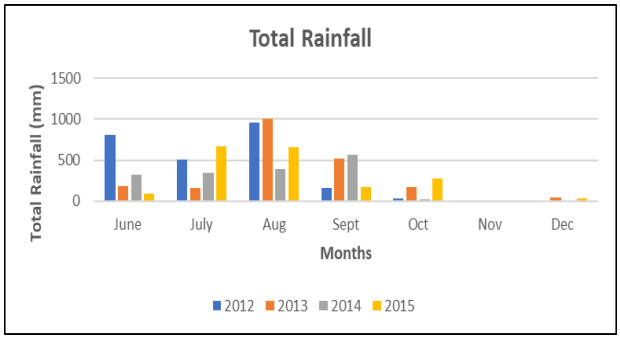

Fig. 5. Total rainfall from June to December 2012-2015 during the growing period of the tomato plants, Agrometeorological Station, MMSU-PAGASA, City of Batac, Ilocos

lowest leaf blight infection in 2014 (7.50%), 2013 (8.70%) and 2015 (12.00%). Lower infection was also observed in plants mulched with dried grasses in 2014 and 2015 at 11.67% and 12.36%, respectively; and in rice straw at 12.95% in WS 2015. The highest leaf blight infection was obtained in plants mulched with sawdust at 52% and plants without mulch at 51%. Sawdust is acidic, making it a good mulch choice for acid-loving plants. As sawdust decomposes, it robs soil of nitrogen, but since sawdust decompose a lot faster, you may have to compensate the addition of nitrogen. Hence, when using sawdust for mulch, growers should take couple simple precautions (https://www.gardeningknowhow.com/garden-how-to/mulch/using-sawdust-as-mulch.htm). Thus, with the presence of nitrogen, it allows the production of blight infection.

Based on the results of the study, some of the different mulching materials used in tomato production were good materials to help the plants to withstand pest incidence. Many non-living materials such as rice straw, dried grasses, sawdust, rice hull, carbonized rice hull have been used to cover the soil in order to prevent insect infestation and weed growth.

Proper combination of management practices and other methods of pest control could be the most logical step in attaining the most economical and effective pest control measure.

Tomato Yield

Significant differences were observed during the WS 2013 and WS 2015 in terms of marketable yield (Table 3). Highest marketable yield per hectare was observed in tomato plants mulched with plastic sheet. However, this was comparable in plots mulched with DG and RS. The lowest were observed from SD and the UM treatment.

According to Mirshekari *et al.*, 2012, as cited by Babatunde and Etukudo (2015), using black plastic instead of bare soil have recorded higher yields, which supported the present results.

During the WS 2012, highly significant differences were obtained, wherein plot mulched with plastic sheet produced the highest marketable yield. This was followed by tomato plants mulched with DG and RS. The lowest were observed from SD and the UM treatment.

It can be noted that DG and RS were good mulching materials in tomato production. High marketable yield was obtained in four consecutive wet season (2012 to 2015). Sufficient amount of moisture was essential for better fruit production of the plants.

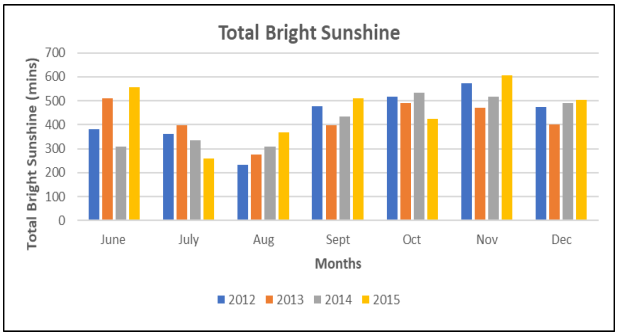

Fig. 6. Total bright sunshine from June to December 2012-2015 during the growing period of the tomato plants, Agrometeorological Station, MMSU-PAGASA, City of Batac, Ilocos Norte

A related study conducted in BPI-Buguias Seedfarm and BPI-Baguio experimental farm shows that mulching dried sunflower leaves in lettuce and broccoli enhanced the production of highest marketable yield (Castillo and Bacayan, 2017). Further, it was noted that its application initiated longer and most number of leaves on lettuce, enhanced production of widest curds on broccoli.

Yield obtained in tomato was comparable during the wet season trials (WS 2012, 2013, 2014 and 2015 trials). High amount of rainfall (323-343mm) favored good growth and development of the plants using all the mulching materials/treatments (Fig. 6). Lower fruit worm infestation during the WS 2014 compared to WS 2012, WS 2013 and WS 2015 (Table 1) might had contributed to the higher marketable yield of the tomato plants.

Commercial tomato growers often use black plastic mulch, it retains heat and usually increases tomato plant growth and yield as compared in plants without the application of mulching materials (control). This plastic

Table 3. Marketable fruit yield of tomato mulched with different materials during the WS 2012 to WS 2015

MULCHING MATERIALS	MARKETABLE YIELD (tha^{-1})				
	WS 2012 **	WS 2013 *	WS 2014 ns	WS 2015 **	Mean
1. Dried Grasses	16.04b	16.6a	50.84	20.14ab	25.91
2. Rice Straw	15.51bc	15.60ab	49.17	21.31ab	25.40
3 Sawdust	12.64e	13.52b	39.67	18.52b	21.09
4. CRH	13.29de	14.03b	43.80	19.65b	22.69
5. Rice Hull	14.41cd	15.29ab	44.02	19.53b	23.31
6. Plastic Mulch	18.46a	16.99a	48.56	24.69a	27.18
7. Unmulched	12.97e	13.22b	39.39	17.35b	20.73
MEAN	14.76	5.06	45.06	20.17	21.26
CV (%)	15.50	23.10	17.80	8.28	

** - significant at 1% level
* - significant at 5% level
ns - not significant
In a column, means marked with the same letter are not significantly different using HSD.

Table 4. Cost and return analysis in tomato production per hectare using different mulching materials

PARTICULARS	DRIED GRASSES	RICE STRAW	SAW DUST	CARBONIZED RICE HULL	RICE HULL	PLASTIC MULCH	UN-MULCHED
A. Labor Cost (P)	42,000	39,500	40,000	41,250	40,000	33,250	48,250
B. Material Cost (P)	98,500	108,000	98,500	98,500	98,500	120,000	98,000
C. Total Production Cost (P)	140,500	142,500	138,500	139,750	138,500	153,250	136,250
D. Average Yield (tha^{-1})	25.91	25.40	21.09	22.69	23.31	27.18	20.73
E. Gross Income @ P20/kg	518,200	508,000	421,800	453,800	466,200	543,600	414,600
F. Net Return (P)	377,700	365,500	283,300	314,050	327,700	390,350	278,350
G. Benefit Cost Ratio (BCR)	2.69	2.56	2.05	2.25	2.37	2.55	2.04

mulch, however, is labor intensive and costly (Patterson Susan, 2016); hence, the use of dried grasses and rice straw is recommended in tomato production.

In an experiment conducted by Inusah, BIY (2013), different types of organic-based mulch such as grass and rice straw used in irrigated onion production significantly improved onion productivity and yields under tropical conditions. Onion bulb mulched with dried grass and rice straw yielded significantly over 60% higher than unmulched.

Profitability of using different mulching materials

Economic analysis of the study indicates that using RS, DG and PM increased marketable tomato fruit yield, hence obtaining a bigger economic returns as compared in the unmulched and other mulching materials.

The labor costs incurred in growing tomato using different mulching materials (Table 4) was lowest with the use of plastic mulch at ₱33,250. Highest net returns, therefore was obtained from tomato mulched with plastic mulch, (₱390,350), followed by dried grasses and rice straw, with net returns of ₱377,700 and ₱365,500, respectively. These data marked a positive effect of using these kind of mulching materials which gave a BCR value of 2.69 (dried grasses), 2.56 (rice straw) and 2.55 (plastic mulch). Black plastic film, effectively suppress most weeds, thereby reducing labor and other costs for weed control (Mark Schonbeck, 2012).

CONCLUSIONS AND RECOMMENDATION

Application of black plastic mulch together with the use of dried grasses and rice straw in tomato production significantly influences plant growth and fruit yield of tomato. Findings show that using black plastic mulch in tomato effectively suppressed weed growth, and reduced labor and other costs for weed control, improved the growing condition for tomato thus improving its competitiveness against weeds.

Farmers who cannot afford the high price of plastic mulch, other mulching materials, such as rice straw and dried grasses could be a good substitute; which produce lesser weed biomass, higher yield and benefit cost ratio as compared to the use of saw dust, rice hull, carbonized rice hull and the unmulched. Satisfactory net return and higher BCR can be obtained from plants mulched with plastic sheet, dried grasses and rice straw. Dried grasses and rice straw are best organic mulching materials in tomato production, and can serve as substitute for plastic mulch, and are recommended for farmers because these effectively suppress weeds, can withstand pest incidence, thus, obtaining higher yield and income.

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