EVALUATION OF ORGANIC MULCHING MATERIALS ON SELECTED HIGHLAND VEGETABLES

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ABSTRACT

The study was conducted in BPI-Buguias Seedfarm and BPI-Baguio experimental farm from December 2013 to March 2016 using lettuce (var.Xanadu, Romaine type) and broccoli (var. Legacy) to evaluate the effects of mulching materials on lettuce and broccoli; identify the appropriatemulching material for lettuce and broccoli; determine the effects of mulching materials on the soil; and compare the profitability of using mulching materials for selected highland vegetables.

Mulching materials such as fern (*Pteridium esculentum)*, sunflower (*Tithonia diversifolia*), alnus (*Alnus sp*.) and grass (*Spergulla arvensis*) were mulched on lettuce and broccoli. Mulching of sunflower leaves enhanced the production of highest marketable yield and lowest nonmarketable yield on lettuce and broccoli. Its applicationinitiated longerand most number of leaves on lettuce, enhanced production of widest curds on broccoli, and suppressed weed growth leading to the lowest weed population count on both crops may be due to its allelopathy effect. Further, mulching sunflower leaves increased potassium content of the soil after harvest due to its easy decomposition while grass mulch retained or conserved the highest soil moisture in broccoli plots.Control produced the lowest marketable yield and registered the lowest soil moisture retained but with highest weed population count in both crops.

Return on investment was highest in mulching sunflower leaves on lettuce and broccoli with 134.55 and 146.33%, respectively, followed by mulching alnus leaves.

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RATIONALE

Growing vegetables organically is not just doing away with synthetic fertilizers and pesticides, but also improving the condition of the soil. There are, however, environmental constraints affecting vegetable growing in the locality. One is drought or very limited water brought by development that contributes to climate change. This situation leads to growing crops difficult and for only once to twice a year. To mitigate this, the use of mulching materials could help in the conservation of soil moisture that would prolong watering intervals as well as improving the soil for crop growth and development.

Limited water or drought is usually experienced towards summer where there is hot weather. According to Firoz et al. (2000) high air temperature causes high soil temperature, which retard root growth and affects the uptake of water, nutrients and photosynthesis that consequently results in stunted growth and mortality of plants.

Advantages in using organic mulch increase the amount of organic matter, aeration of soil and upon decomposition increase water holding capacity which is important in hot weather and long days. Mulching helps maintain uniform temperature, increase effectivity of fertilizers and improve irrigation efficiency (AVRDC, 1990, and Benoit and Ceustermans, 1996). Organic mulches act as insulators, keeping the soil warm during cool weather and keeping cool during the hot months of the year. Some of these mulches also decrease pest infestation, minimize soil erosion and prevent weed problem thereby reducing competition for light, water and nutrients. Mulching also reduce cost of labor in weeding and watering.

Vegetables such as lettuce and broccoli are short duration crops, easy to grow and are appropriate in areas with limited irrigation. They are good sources of nutrients as in vitamin A, C, K, beta-carotene, folate and mineral, manganese and certain phytonutrients. Broccoli contains phytonutrients sulforaphane and indoles, with abundant levels of antioxidants and anti-cancer. Definitely, there is a need to increase production and improve quality of vegetables for healthy population, hence this study.

LITERATURE CITED

Moniruzzaman (2006) stated that lettuce is a cool crop. The optimum mean temperature range for excellent growth and good quality of lettuce is 15- 25^{o}C and temperature above 25^{o}C accelerates seed stalk and reduces the quality of leaves (Rashid, 1999). It is evident that high air temperature causes high soil temperature, which retard root growth and affects the uptake of water and nutrients and photosynthesis that consequently results in stunted plant growth and mortality (Firoz etal., 2000). One way of solving this problem is mulching, which has various effects on the soil and plants. Mulching helps to maintain uniform temperature, control weed, increases effectivity of fertilizers, conserve soil moisture and improves irrigation efficiency (AVRDC, 1990 and Benoit and Ceustermans, 1996).

Mulching is any material used to cover the surface of the garden soil to conserve soil moisture, protect plant roots from heat and cold for better plant growth and development. A popular mulching material is rice straw which is always available in the farmer's field and

when this indigenous material is used as mulch, it enhances vegetative growth by reducing soil moisture depletion and temperature (Kuo and Tsay, 1981). Also, Causon et.al (2001) stated that a mulch layer of paper, horse manure, straw and wild plants on the soil help vegetables to grow faster and healthier with less labor. All the three crops, broccoli, turnips, and cauliflower showed that the mulch helped them to grow better. No negative effects were seen on the crops that could have been caused by the mulch. Moreover when the crops are harvested the mulch layer can be mixed into the soil to enrich fertility.

Ashworth and Harrison (1983) also reported that mulching Chinese cabbage posted positive result where loss of nutrients due to leaching reaction of soil was may be reduced because of soil moisture conservation. Moniruzzaman (2006) showed that spacing and mulching showed significant effect on yield components of lettuce. The highest fresh yield of lettuce was obtained from the closest spacing (40 X 20 cm) from the mulched plants than unmulched plants. The highest yield was (25.9 t/ha in 1999 and 28.3t/ha 2000 with an average of 27.10 t/ha. The results also revealed that higher gross return was obtained from the closest spacing in combination with mulch.

Kato et al. (2005) evaluated sunflower (*Helianthus annuus L.*) and wild sunflower (*Tithoniadiversifolia* (Hemsl) A. Gray) and found that ethyl acetate-soluble fractionsof exudates from seeds inhibited fungal germination. Seeds in wild sunflower contains sumdiversifloide (4, 15-dinor-3hydroxy-(5)-xanthene-12, 8-olide), which has allelopathyeffect as in sunflower fruits.Anaya (1999) also mentioned that sunflower (*Helianthus annuus*) shows strong weed suppression. He concluded that soil incorporation of sunflower residues suppressed density of dicot weeds by 60% and straw inhibited plant height of wild oat, *Agropyronrepens*, *E. crus-galli*, *Ambrosia artemisiifolia* and lambsquarter. According to Birkett et al. (2001), incorporation of sunflower residues into the soil accounts for substantial weed suppression. Reduced weed count and biomass was reflective of the inhibitory effects of sunflower residue mediated by the presence of phytotoxic allelochemicals which are released during decomposition in their immediate vicinity. Further, Macias et al.(2002), and Anjum and Bajwa (2005) reported that sunflower contains several allelochemicals responsible for biological activity, viz, chlorogenic acid, isochlorogenic acid, a-napthol, scopolin, and annuionones. Inhibitory against broad-leaved weeds has also been reported by Leather(1983) and Anjum and Bajwa (2007) and described as selective in nature (Khanh et al., 2005).

Karimmojenii et al. (2011) found that *Amaranthusretroflexus* was the most sensitive to sunflower allelopathy, and *Portulacaoleracea* was the most resistant. As extract concentration increased from 25 to 100%, the inhibitory effect on germination indices increased, while 25% extract concentration was observed to have stimulating effects on wheat and *P.oleracea* germination. The Megasun sunflower cultivar was the most effective and Hysun36 has the least effect on the target plants. Megasun extract at 100% concentration effectively suppressed over 80% of selected weeds. The results indicate that the allelopathic properties of some sunflower cultivars can affect noxious weed species such as *H. spontaneum* and *L. rigidum* in wheat and *A. retroflexus* in safflower.

Salisburry and Ross (1992) stated that wilting point moisture content of the soil is -1.5 MPa for agricultural crops (older literature considered the wilting point a -15 bars).In thethe booklet of Soil Moisture Meter manufactured by Lincoln Irrigation, the wilting point of lettuce is 6–8 and broccoli is 4-6 WP meter reading.

OBJECTIVES

1. To determine the effect of different mulching materials on the performance of lettuce and broccoli;
2. To identify appropriate mulching materials for lettuce and broccoli;
3. To determine the effects of mulching materials on the properties of the soil; and
4. To compare the profitability of using different mulching materials for lettuce and broccoli.

METHODOLOGY

The study was conducted in BPI BuguiasSeedfarm and BPI-Baguio experimental farm on December 2013 to March 2016 using lettuce (var. Xanadu) and broccoli (var. Legacy) as test crops.

Prior to land preparation, the trial sites were described. Likewise, composite soil samples were taken from the experimental area and submitted to the Bureau of Soils laboratory, Pacdal, Baguio City for soil analysis.

An area of 100 square meters was thoroughly prepared into raised beds consisting of 15 plots measuring 1 x 6 sq. m. Before planting, vermicompost at the rate of 5 tons/ha was applied basally and mixed into the soil. Seedlings were transplanted in the beds double row with a distance of 20X30 cm for lettuce and 30 X 40cm between hills and rows for broccoli.

The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments were: control, fern (*Pteridiumesculentum)*, sunflower (*Tithoniadiversifolia*), alnus(*Alnus sp*.)and grass(*Spergullaarvensis*). These organic materials are very much available in the locality and can be taken free and used for organic vegetable production.

Collected mulching materials were air dried for 2 weeks and spread into the beds 1 cm thick enough to cover the soil when the plants were established at 2 weeks. Meanwhile, watering was done every four days. Hilling-up and weeding were not carried out during the crop growth duration because will be counted.

The general data gathered for the test were:

1. Initial and final analysis of the soil. The initial and final pH, OM, P and K were taken before and after planting.
2. Moisture content (%). Soil samples (100 grams) were collected weekly from the different treatment plots then oven dried at 70^{o}C for two days for soil moisture analysis using the formula below:

$$\text{Moisture content (\%)} = \frac{\text{Fresh Weight – Oven Dry weight}}{\text{Fresh weight}} \text{X100}$$

3. Weed population. Weeds were counted from an area of 60 sq.cm per plot, one week before harvesting.
4. Cost and return analysis

Lettuce

Ten sample plants were selected at random and used during gathering data.

a. Leaf length (cm).Plants were measured from the base to the tip of the plants.
b. Leaf width (cm). During harvest, leaf sample from plants were measured at the widest part.
c. Number of leaves. During harvest, leaves of randomly selected sample plants were counted.
d. Plant canopy diameter (cm).During harvest, plant canopy sample plants were measured at the widest.
e. Marketable yield (tons/ha). Heads which aredisease and damage-free were weighed during harvest.
f. Non-marketable yield (tons/ha). Diseased and damaged produce were separated and weighed at harvest.
g. Incidence of insect pests and diseases. Incidence of insect pests and diseases attacking the crop were monitored,identified and assessed during the cropping period.

Broccoli

Ten sample plants were selected at random and used during gathering data.

a. Plant height (cm). Plants were measured from the base to the tip of the curd at floweringstage (1 peso coin size).
b. Curd diameter (cm). Curds were measured at the widest part.
c. Marketable yield (tons/ha). These were harvested curds free from damages and diseaseinfection
d. Non-marketable yield (tons/ha). These were diseased and damaged, and very small curds.
e. Incidence of insect pests and diseases. Incidence of insect pests and diseases attacking the crop was monitored, identified and assessed during the cropping period.

Statistical Analysis

The data gathered were subjected to variance analysis and mean separation test by Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Description of the Site

The first trial site was a transition for organic farm in BuguiasSeedfarm. The area is 2,060masl (high elevation), slightly sloping with silty loam soil which is friable, previously planted with cabbage, experiences low temperature for as low as 5^0C for the months of December 2013 to January 2014, and no problem on water runoff from other farms.

The second trial site in Baguio on December 2014 to March 2015 was previously planted with squash then fallowed for two years. The area is 1,350 masl (mid elevation), surrounded by a concrete irrigation canal and no water flow problem coming from other paddies. Further, the area has a clay loam soil, and the surrounding areas were planted with indigenous vegetables and legumes practicing organic and inorganic farming, respectively.

Mulching materials

The mulching materials especially sunflower, fern and grass are very much available in the locality. In the past decades, farmers use dried rice straw as mulching material for their crops especially on strawberry but at present plastic mulch became common which can be recycled. However, marginal farmers use some weeds for mulching their chayote and other crops. Sunflower leaves started to rot after one month while the other mulching materials have same state up to harvest which may attributed nutrients in which the soil enhancing the growth of plants particularly leaf length number of leaves, marketable yield and affected soil properties.

Leaf length and width

There were significant differences among treatments on leaf length (Table 1). Lettuce mulched with sunflower leaves had the longest leaves with an average length of 22.30 cm. followed by lettuce mulched with fern and weed grass with 21.30 and 21.26 cm, respectively. The shortest was obtained from unmulched with 18.11 cm. No significant differences were observed on the width of leaves as affected by the application of mulching materials with range of 9.36 to 10.57 cm.

Table 1. Leaf length and leaf width of lettuce as affected by mulching materials

Treatment	Length leaf (cm)		Mean	Leaf width (cm)		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	19.50^{e}	16.73^{c}	18.11^{c}	8.70	10.03	9.36
Fern	22.80^{b}	19.80^{b}	21.30^{ab}	9.30	10.56	9.93
Sunflower	23.30^{a}	21.33^{a}	22.30^{a}	10.30	10.85	10.57
Alnus	21.76^{d}	19.60^{b}	20.68^{bc}	9.93	1055	10.24
Grass	22.00^{c}	20.53^{ab}	21.26^{ab}	9.96	10.47	10.22
Significance	**	**	**	ns	ns	ns
CV (%)	2.7	5.5	2.95	6.13	24	18

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

Number of leaves

Lettuce mulched with sunflower produced the highest number with 24 leaves followed by plants mulched with grass while the lowest was from unmulched plots with 19 leaves (Table2).

Canopy diameter

Plants applied with different mulching materials gave comparable plant canopy diameter ranging from 20.31 to 21.66 cm and the narrowest canopy was from the unmulched plants with 18.15 cm. The wider plant canopy of mulched plants could be due to the effect of mulches that conserved soil moisture for plant growth and development.

Table 2. Number of leaves and plant canopy diameter of lettuce as affected by mulching materials

Treatment	No. of leaves		Mean	Plt Canopy dia. (cm)		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	14	25[d]	19[c]	17.16[d]	19.13[b]	18.15[b]
Fern	14	28[c]	21[b]	19.13[c]	21.50[a]	20.31[a]
Sunflower	14	34[a]	24[a]	20.96[a]	22.36[a]	21.66[a]
Alnus	15	30[b]	22[b]	19.86[bc]	21.66[a]	20.76[a]
Grasses	15	31[b]	23[b]	20.33[ab]	22.33[a]	21.33[a]
Significance	ns	**	**	**	**	**
CV (%)	19.69	3.8	6.21	6.9	5.4	21

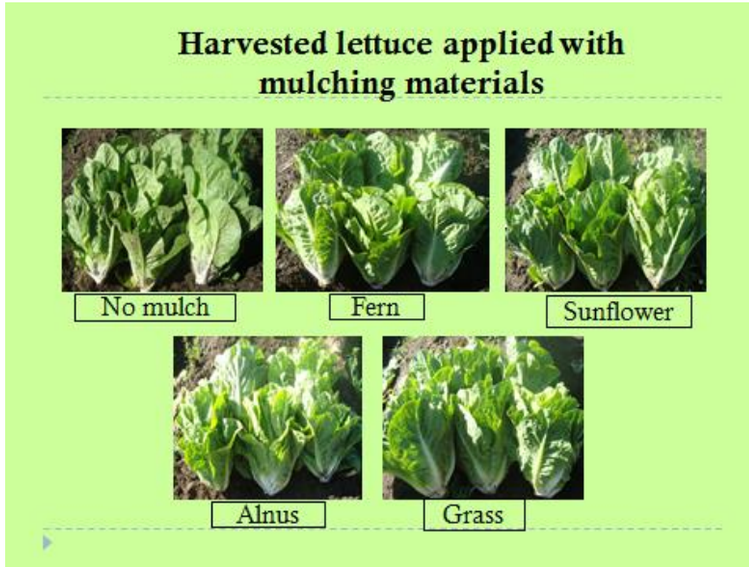
Means with the same letter in a column are not significantly different at 5% level by DMRT.

Marketable yield

There were significant differences observed on yield as affected by mulching materials (Table 3 and Fig. 1). Plants mulched with sunflower produced the highest yield with an average of 30.91 t/ha followed by alnus mulched plants with 28.76 t/ha. Plants mulched with fern and grasses produced mean yield of 26.19 and 24.59 t/ha, respectively. Plants without mulch produced the lowest marketable yield of 20.69 t/ha. The highest marketable yield in sunflower mulched plants could be due to higher number and longer leaves. Further, lesser weed count was noted from sunflower mulched plants thereby reduced in the competition for light, water and nutrients leading to increased yield.

Overview of the Trials

BPI-BuguiasSeedfarmBPI-Baguio Experimental Farm



Non marketable yield

Higher nonmarketable weight was recorded significantly from unmulched plants with 3.57 t/ha compared to those applied with different mulching materials with yields ranging from 2.00 to 2.25 t/ha.

Incidence of insect pest and diseases

No pest infestation was observed on lettuce during the growth duration of the plants. Soft rot disease infection was insignificantly observed only towards harvesting stage.

Table 3. Marketable and nonmarketable yield of lettuce as affected by mulching materials

Treatment	Marketable (t/ha)		Mean	Non marketable (t/ha)		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	14.38^{d}	27.00^{c}	20.69^{d}	3.65^{a}	3.50	3.57^{a}
Fern	19.56^{c}	32.83^{b}	26.19^{bc}	2.08^{b}	2.00	2.04^{b}
Sunflower	27.32^{a}	34.50^{a}	30.91^{a}	2.25^{b}	1.75	2.00^{b}
Alnus	21.53^{b}	36.00^{a}	28.76^{ab}	2.00^{b}	2.03	2.02^{b}
Grass	19.66^{c}	29.53^{bc}	24.59^{c}	2.50^{b}	2.0	2.25^{b}
Significance	**	**	**	**	ns	**
CV (%)	4.0	7.9	5.75	5.9	13	11

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

Soil moisture analysis of plots planted to Lettuce

Significant effects of mulching materials were noted on moisture content of the soil in two locations (Table 4). Plots mulched with grasses had the highest moisture content of 24.59% while control had the lowest with 18.15%. Plots with other mulches had comparable moisture content of 22.21 to 23.33%. High moisture content indicated that

grasses, alnus and sunflower are effective in preventing water loss through evaporation. Salisburry and Ross (1992) stated that wilting point moisture content of the soil is -1.5 MPa for agricultural crops (older literature considered the wilting point a -15 bars). In the booklet of Soil Moisture Meter manufactured by Lincoln Irrigation, the wilting point of lettuce is 6–8 meter reading.

Weed population

Significant differences were noted on weed counts as affected by different mulching materials (Table 4). Lettuce plots mulched with sunflower showed the lowest weed count with a mean of 15 per 60 sq. cm. followed by plots with alnus and fern with 21 and 23 count, respectively. The lowest weed count was may be due to substances from sunflower leaves that suppressed the growth of weeds. According to Anaya (1999) sunflower residues suppressed density of dicot weeds by 66%. Likewise, Rukhama et al (2007) mentioned that sunflower leaf extracts contain allelochemicals that has a potential as natural herbicide against broad weeds. Unmulched plants had the highest weed counts of 58.

Table 4. Soil moisture content and weed count of plots planted to lettuce as affected by mulching materials

Treatment	Moisture Content (%)		Mean	Weed Count		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	18.45^{b}	17.84^{c}	18.15^{c}	65^{d}	52^{a}	58^{d}
Fern	24.60^{a}	19.83^{abc}	22.21^{b}	25^{b}	22^{b}	23^{b}
Sunflower	26.66^{a}	19.38^{bc}	23.02^{b}	16^{cd}	14^{c}	15^{a}
Alnus	24.83^{a}	21.82^{a}	23.33^{b}	22^{bc}	20^{b}	21^{b}
Grass	28.45^{a}	20.74^{ab}	24.59^{a}	25^{b}	42^{a}	33^{c}
Significance	**	**	**	**	**	**
CV (%)	7.2	5.6	2.7	11.44	29	4.2

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

Initial and final analysis of the soil

Buguias and Baguio experimental areas have initial soil pH of 6.20 and 5.67, respectively which are within the pH requirement of lettuce (Table 5). In Buguias the soil had high organic matter of 15%, 350ppm phosphorus and 270 ppm potassium. In Baguio it was observed that there is low organic matter of 2%, phosphorous with 125% ppm and higher potassium content of 444ppm.

In Buguias**, s**oil pH was decreased as affected by mulching materials with a range of 5.45 to 5.55 while Baguio had increased to a range of 5.93 to 6.17 (Table 5). All mulched plots had decreased in organic matter to 10% in Buguiasmay be due to plant absorption or leaching for having silty loam soil, and in Baguio also decreased in fern and alnus applied plots except plots with sunflower and grasses including the control that remained at 2 %.

Phosphorous also decreased in all treatment plots for about 115 to 120 ppm from 350 to as low as 225 ppm in Buguias while about 31 to 54 decrease from 125 ppm to as low

as 71 ppm. Potassium also decreased in all treatments except with sunflower in Buguias and sunflower and grass in Baguio. The decrease of phosphorous and potassium may mean that plants absorbed nutrients for their growth and development. The increase in potassium could due to the easy decomposition of sunflower leaves. Nagarajah and Amarasiri (1977) stated that wild sunflower has higher potassium content compared to the other plant used as green manure, and Yala and Maha (1974 and 1975) stated that 1 ton of wild sunflower provides 5.7 kg N, 1kg P_2O_5 and 10.6 kg of K_2O.

Table 5. Chemical analysis of the soil beforeplanting and at harvest of lettuce

Treatments	pH		OM (%)		P (ppm)		K (ppm)	
	Bugiuas	Baguio	Bugiuas	Baguio	Bugiuas	Baguio	Bugiuas	Baguio
No mulch	5.50	5.93	10	2.0	225	73	110	384
Fern	5.50	6.17	10	1.5	230	94	114	366
Sunflower	5.46	6.03	10	2.0	230	79	315	672
Alnus	5.55	6.15	10	1.5	230	88	115	374
Grasses	5.45	6.12	10	2.0	230	71	114	480
Initial analysis	6.20	5.67	15	2.0	350	125	270	444

Return on investment

Economic analysis revealed that lettuce mulched with sunflower had the highest net income return on investment of 134.55% followed by alnus mulched plants with 118.27% (Table 6 and Appendix Table1). Fern and Grasses mulched plants obtained intermediate ROIs of 98.79% and 86.64%, respectively. Moreover, unmulched plants posted the lowest 62.52%.

Table 6. Return on investment of lettuce

Treatments	Production Cost (Php)	Yield (t/ha)	Less 10% spoilage & price fluctuation (Php15/kg)	Gross Income	Net Income	ROI(%)
No mulch	17,1850	20.69^{d}	18.62	279,300	107,450	62.52
Fern	177,850	26.19^{bc}	23.57	353,550	175,700	98.79
Sunflower		30.91^{a}	27.81	417,150	239,300	134.55
Alnus		28.76^{ab}	25.88	388,200	210,350	118.27
Grasses		24.59^{c}	22.13	331,950	154,100	86.64

Broccoli

Plant height

Plant heights differed significantly as influenced by the different mulching materials (Table 7). Plants mulched with different materials had comparable heights ranging from 23.75 to 24.92cm compared to the unmulched plants which were shorter with 20.11 cm. The shorter plants could be due to low soil moisture content resulting in stunted growth. Literature stated that high air temperature causes soil high temperature which retard root

growth and affects the uptake of water nutrients and photosynthesis that consequently results in stunted growth and mortality of plants (Firoz, et al 2000).

Curd diameter

Plants mulched with sunflower significantly produced the widest curd with mean of 11.01 cm followed by alnus, grass and fern with 10.15, 9.84 and 9.45cm, respectively. Wider curds were may be because of nutrients given by sunflower leaves boosting the growth of curds. Likewise may be due to sunflowerallelopathy, on grass, plants and weeds(Anjum and Bajwa, 2007; Macias et al., 1998; Macias et al., 1999),thus no competition for light, nutrients, and space contributing to wider curds.Although some researchers have found that allelopathic sunflower material inhibits wheat growth, our results suggest that sunflower allelopathy can improve the growth of crops such as lettuce and broccoli. Unmulched plants gave the lowest curd diameter of 7.17 cm maybe due to lowest soil moisture content and highest number of weeds that competed for the absorption of nutrients leading to slow growth of plants (Table7).

Table 7. Plant height and curd diameter of broccoli as affected by mulching materials

Treatment	Plant height (cm)		Mean	Curd diameter (cm)		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	15.36^{b}	24.85^{c}	20.11^{b}	5.70^{d}	8.63^{b}	7.17^{d}
Fern	18.70^{a}	28.81^{b}	23.75^{a}	8.83^{bc}	10.06^{b}	9.45^{c}
Sunflower	19.83^{a}	30.01^{a}	24.92^{a}	9.96^{a}	12.05^{a}	11.01^{a}
Alnus	18.83^{a}	29.05^{b}	23.94^{a}	9.45^{ab}	10.84^{b}	10.15^{b}
Grass	19.20^{a}	29.99^{b}	24.59^{a}	9.26^{ab}	10.42^{a}	9.84^{bc}
Significance	**	**	**	**	**	**
CV (%)	5.91	4.85	5.5	9.4	10	7.0

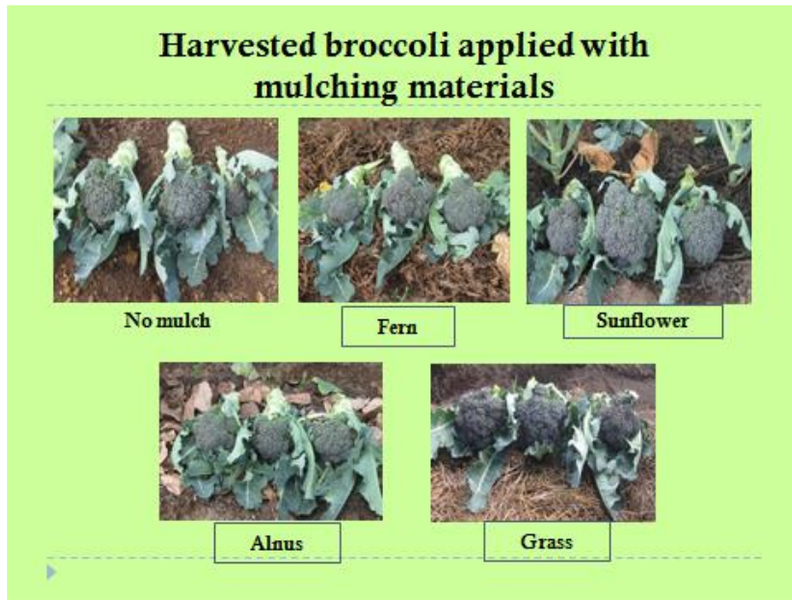
Means with the same letter in a column are not significantly different at 5% level by DMRT.

Marketable yield

Marketable curd from plants mulched with sunflower was significantly the heaviest with 19.43 tons/ha followed by curds produced by plants mulched with alnus with 17.19 tons/ ha (Table 8 and Fig. 2). This was may be due to wider curd diameter. Plants mulched with grasses and fern had marketable yields of 16.00 and 15.85 t/ha, in order, while the lowest marketable yield of 9.31 tons /ha was obtained from the unmulchedplants.The study confirmed that advantages in using organic mulch increase affectivity of fertilizers and improve irrigation efficiency (AVRDC, 1990).

Overview of the Trials

BPI-BuguiasSeedfarm BPI-Baguio Experimental Farm



Non marketable yield

Highest non marketable weight of curds was significantly taken from unmulched plants with 4.05 t/ha (Table 8). This was may be due to narrow curd diameter brought by lower soil moisture content that affected the curds. Broccoli mulched with different mulching materials produced lower non marketable yields ranging from 1.89 to 2.16 tons/ha (Table8).

Table 8. Marketable and nonmarketable yield of broccoli as affected by mulching materials

Treatment	Marketable (ton/ha)		Mean	Non marketable (t/ha)		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	8.13[d]	10.49[c]	9.31[d]	4.03[a]	4.06[a]	4.05[a]
Fern	16.10[c]	15.60[b]	15.85[c]	2.04[b]	1.97[b]	2.01[b]
Sunflower	17.02[b]	21.84[a]	19.43[a]	2.10[b]	1.93[b]	2.02[b]
Alnus	17.89[a]	16.49[b]	17.19[b]	1.86[b]	1.92[b]	1.89[b]
Grass	16.09[c]	15.91[b]	16.00[c]	2.23[b]	2.09[b]	2.16[b]
Significance	**	**	**	**	**	**
CV (%)	2.0	7.5	30.6	13.0	7.11	13.3

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

Insect pest and disease incidence

The population of pest in broccoli was noted very minimal. Also no disease incidence on plants was observed throughout the cropping season. Cover crop mulches positively affect pest management by suppressing weeds and other pests and reducing runoff or ground water infiltration of pesticides and nutrients (Harrison et al., 2004)

Weed population

Significant differences were observed on weed counts as affected by the different mulching materials (Table 9). Plots applied with sunflower showed the lowest weed count of 19 per 60 sq. cm may be due to sunflower residues that suppressed the growth of weeds. This was followed by plots mulched with fern, alnus and grasses with 43, 54 and 55, respectively. Plots without mulch had the highest weed count of 104.Karimmojenii et al.,(2011) suggest that using sunflower allelopathycontrol broad-leaf weeds, such as (*Amaramthus reteroflexus*), may at the same time control narrow-leaf weeds such as H. spontaneum and L. rigidum.

Identified weeds in the trial area

It was noted in Buguias that there were four species of weeds identified such as Galinsoga: (*Galinsoga parviflora)*, Johnson grass: (*Sorghum halepens)*, Knot grass: (*Setariare vechnii)* and Spurrey or Spurry: (*Spergula arvensis)* while in Baguio were seven species of weeds namely; Knot grass, Wiregrass, Johnson grass,Galinsoga, Beggartik (Poriket)(*Bidensfrondosa*),Pigweed or Purseley*(Portulaca oleracea),*andProstrate Amaranth(*Amaranthus deflexus).*

Weeds Identified

Knot grass (*Setariarevechnii*)

Wire grass (*Eleusineindica*)

Johnson grass(*Sorghum halepense)*

Spurrey or Spurry(*Spergulaarvensis*)

Prostrate Amaranth(*Amaranthusdeflexus*)

Pigweed (*Portulacaoleracea*)

Galinsoga (*Galinsogaparviflora*)

Beggartick (Puriket) (*Bidensfrondosa*)

Soil moisture analysis

Significant effects of mulching materials were noted on moisture content of the soil (Table 9). Plots mulched with the different materials comparable moisture content ranging from 27 to 29.09 % while unmulched plots had lower with 15.88%. High moisture contents indicated that grass, fern, alnus and sunflower are effective in preventing water loss through evaporation. Pliszka et al., (1997) stated that mulches prevent evaporation and enriches the soil organic matter, and therefore, helps conserving soil moisture.Salisburry and Ross (1992) stated that wilting point moisture content of the soil is -1.5 MPa for agricultural crops (older literature considered the wilting point a -15 bars). In the booklet of Soil Moisture Meter manufactured by Lincoln Irrigation, the wilting point of broccoli is 4-6 WP meter reading.

Table 9. Soil moisture and weed population from plots planted to broccoli as affected by different mulching materials

Treatment	Moisture Content (%)		Mean	Weed Population		Mean
	Buguias 2014	Baguio 2015/2016		Buguias 2014	Baguio 2015/2016	
No mulch	15.49^{c}	16.00^{c}	15.88^{b}	99^{e}	109^{e}	104^{a}
Fern	23.56^{a}	24.61^{a}	29.08^{a}	38^{b}	49^{b}	43^{d}
Sunflower	21.65^{b}	22.35^{b}	27.00^{a}	19^{a}	20^{a}	19^{e}
Alnus	23.56^{a}	24.61^{a}	29.08^{a}	55^{d}	53^{c}	54^{c}
Grasses	21.65^{b}	22.35^{b}	27.00^{a}	40^{c}	70^{d}	55^{b}
Significance	**	**	**	**	**	**
CV (%)	8.50	7.19	4.00	2.60	3.00	1.77

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

Soil analysis before planting and at harvest

A slight decrease in soil pH was noted in all treatments in both locations from 6.20 (Buguias) and 6.13 (Baguio) to as low as 5.53 and 5.52, respectively (Table 10). In Buguias soil organic matter decreased from 15 to 12.5 % in all the treatments may be due to plant absorption or leaching while in Baguio was the same at 2%.

On phosphorous all the treatment plots tremendously decreased from 140 and 100 ppm to as low as 2 and 4 ppm, in order, in both locations which means that plants absorbed much of the nutrients for their growth and curd development. Moreover plots mulched with sunflower increased in potassium content 500ppm from 430 ppm 250ppm from 216ppm in two locations maybe due to the faster decomposition that supplied nutrients to the soil. The results confirm that wild sunflower (*Tithonia diversifolia*) is a good green manure with high potasium content (Nagarajah and Amarasiri, 1977).

Table 10. Chemical analysis of the soil before planting andat harvest of broccoli

Treatments	pH		OM(%)		P(ppm)		K(ppm)	
	Bugiuas	Baguio	Bugiuas	Baguio	Bugiuas	Baguio	Bugiuas	Baguio
No mulch	5.53	5.52	12.5	2.0	4	7	150	306
Fern	5.50	5.57	12.5	2.0	2	4	149	270
Sunflower	5.55	5.55	12.5	2.0	2	4	250	500
Alnus	5.55	5.50	12.5	2.0	2	4	150	260
Grasses	5.60	5.46	12.5	2.0	4	4	150	260
Initial analysis	6.20	6.13	15.0	2.0	140	100	216	430

Return on Investment

Table 11 and Appendix Table 2 shows the return on investment of broccoli using different mulching materials with positive returns at varying levels. With the computed total cost of production per ha of 177,500 in one cropping season, sunflower mulch generated the highest return on investment of 146.33 % followed by plants mulched with alnus with 117.88 %. Plants mulched with grass had ROI of 103.38% and fern with 100.98%. The unmulched plants gave the lowest ROI of 22.01%.

Table 11. Return on investment of broccoli

Treatments	Production Cost	Yield (tons/ha)	Less 10% spoilage & price flactuation (Php25.00/kg)	Gross Income	Net Income	ROI(%)
No mulch	171,500	9.31	8.37	209,250	37,750	22.01
Fern	177,500	15.85	14.27	356,750	179,250	100.98
Sunflower		19.43	17.49	437,250	259,750	146.33
Alnus		17.19	15.47	386,750	209,250	117.88
Grasses		16.00	14.40	361,000	183,500	103.38

Agro climatic condition

The first trial in Buguias Seedfarm from December, 2013 to February, 2014 had temperature ranging from 8-11^{o}C while no rainfall observed effected with no pest infestation while insignificant rotting was noted in lettuce towards harvesting.

Second and third trials were conducted in Baguio experimental farm from December, 2014 to February, 2015 and January, 2016 to March, 2016, respectively (Table 12).It was noted on the second trial that temperature ranged from 17.0-17.6 ^{o}C with an average relative humidity of 83.67% and7.3 to 11.3 mmaverage rainfall in January and February, 2015.

In the third trial, temperature in January to February was 18 ^{o}C while higher temperature of 28.05^{o}C was noted in March and no rainfall during the cropping season. There were no pest infestation and occurrence of diseases. No diamond back moth noted in broccoli may be due to the release of *Diadegma* during the vegetative stage.

Since there were no or little rainfall recorded during the three trials, it is then imperative to use mulching materials for the conservation of soil moisture for the growth and development of the crops.

Table 12.Agroclimatic condition from 2013 to 2016

Time	Temperature(^{o}C)	Relative Humidity (%)	Rainfall (mm)
First Trial(Buguias)			
December 2013	8	-	0
January 2014	8	-	0
February 2014	11	-	0
Second Trial (Baguio)			
December 2014	17.0	84	0
January 2015	17.0	84	11.3
February 2015	17.6	83	7.3
Third Trial (Baguio)			
January 2016	18.6	79	0
February 2016	18.6	82	0
March 2016	28.0	83	0

SUMMARY

Lettuce

Mulching materials significantly affected leaf length, number of leaves, plant canopy, marketable and nonmarketable yield. Lettuce mulched with sunflower leaves significantly produced longer and the most number of leaves and higher marketable yield.

On weed population, mulching sunflower followed by alnus had significantly suppressed more weeds. There was no insect pest observed and minimal rotting was noted towards harvesting stage.

Broccoli

Mulching materials significantly affected plant height, curd diameter, marketable and nonmarketable yield. Plants mulched with sunflower produced the widest curds, highest marketable and lower non marketable yield.

On weed population, mulching sunflower leaves had suppressed more weeds.Also larvae of Lipidopterous insects were seen insignificantly towards harvesting while there was no disease incidence observed during the crop growth duration.Soil Analysis

On moisture content, mulching of grasses retained the highest soil moisture on plots planted to lettuce while all mulches were comparable in holding moisture on plots planted to broccoli.

On chemical analysis, Soil pH decreased in all treatment plots in Buguias but increased in Baguio on lettuce, but on broccoli decreased in both locations. Likewise, observations showed decreased organic matter in Buguias and some remained in Baguio. There was also decreased in phosphorus in both locations. Moreover, decreased of potassium in both locations was noted except sunflower and grass on lettuce and sunflower on broccoli.

Return on Investment

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Mulching of sunflower on lettuce and broccoli generated the highest return on investment of 134.55 and 146.33%, followed by mulching alnus with 118.27 and 117.88 %, respectively. Lowest ROI was taken from the unmulched plants with 62.52 and 22.01 %, in order.

CONCLUSION

Based from the results mulching materials significantly enhanced the growth and development of lettuce and broccoli plants. Mulching sunflower leaves enhanced longer leaf length and most number of leaves leading to the highest marketable yield on lettuce; initiated the production of widest curds resulting in highest marketable yield on broccoli, and generated highest net income and ROI.

Mulching alnus leaves also produced higher marketable yield both on lettuce and broccoli. Sunflower leaves as mulching material is effective in suppressing weeds may be due to its allellopathy effect, increased the potassium content of the soil after harvest of lettuce and broccoli. All mulching materials were comparable in conserving soil moisture and enhanced the decrease in pH, organic matter and phosphorus nutrients in the soil.

RECOMMENDATION

As a result of the series of evaluation, sunflower leaves as mulching material on lettuce and broccoli is recommended for producing highest yield and highest ROI and for effectively suppressing weeds.

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APPENDICES

Appendix Table 1. Cost and Return of Lettuce with mulching material*

I.**Cost of Production**		
A. Labor Cost Operation/Activity	Man/Days (Php300/day)	Value (Php)
1. Seedling tray preparation and care of seedlings	15	4,500
2. Plastic roofing installation for seedling protection	2	600
3. Land clearing	25	7,500
4. Plowing/plot preparation	30	9,000
5. Transplanting	30	9,000
6. Collection of mulching materials and application	20	6,000
7. Care and maintenance (weeding, fertilization and watering)	80	24,000
8. Harvesting	20	6,000
9. Sorting and packing	10	3,000
Sub-Total		**68,100**
B.Cost of Inputs, Supplies and Materials	Quantity	Value (Php)
1. Seeds	200g @1,500/50g	6,000
2. Vermi Compost	160 bags @250/bag	40,000
3. Botanical pesticide	2li @ 500/li	1,000
4. Carton/plastic	1,500 @ 10/pc	15,000
5. Garden hose	10 roll @ 1800/roll	18,000
6. Wire (for roof)	1kg @ 150/kg	150
7. Plastic sheet (roofing)	15 kg @ 200/kg	3,000
8. Bamboo posts (for roof)	10pcs @ 20/pc	200
Sub-Total		**83,350**
C.Tools and Equipment		Depreciation Cost
1. Knapsack sprayer	2 units @ 2,500/unit	500
2. Rake	5 pcs @ 250/pc	125
3. Grab hoe with handle	8 pcs @ 350/pc	280
4. Shovel	3 pcs @ 650/pc	190
5. Cythe	8 pcs @ 1175/pc	140
6. Trowel	8 pcs @ 175/pc	140
7. Knife	5 pcs @ 50/pc	250
Sub-Total		**1,400**
D. Land rent, 10,000.00 sq. m @ 25,000/3 months		**25,000**
Total Cost of Production		**177,850**

*Modified from cost and return analysis of major commodities for farm diversification (1990).

Cost of labor, inputs and equipment were based on 2015 prices.

Treatments	Production Cost (Php)	Yield (tons/ ha)	Less 10% spoilage & price fluctuation (Php15/kg)	Gross Income	Net Income	ROI (%)
No mulch	17,1850	20.69	18.62	279,300	107,450	62.52
Fern	177,850	26.19	23570	353,550	175,700	98.79
Sunflower		30.91	27810	417,150	239,300	134.55
Alnus		28.76	25880	388,200	210,350	118.27
Grasses		24.59	22130	331,950	154,100	86.64

Appendix Table 2. Cost and Return of Broccoli with mulching material*

I.**Cost of Production**		
B. Labor Cost Operation/Activity	Man/Days (300/day)	Value (Php)
1. Seedling tray preparation and care of seedlings	10	3,000
2. Plastic roofing installation for seedling protection	2	600
3. Land clearing	25	7,500
4. Plowing/plot preparation	30	9,000
5. Transplanting	30	9,000
6. Collection of mulching materials and application	20	6,000
7. Care and maintenance (weeding, fertilizationand watering)	80	24,000
8. Harvesting	20	6,000
9. Sorting and packing	10	3,000
Sub-Total		**68,100**
B.Cost of Inputs, Supplies and Materials	Quantity	Value (Php)
10. Seeds	350g @500/10g	17,500
11. Vermi Compost	160 bags @250/bag	40,000
12. Botanical pesticide	2li @ 300/li	600.00
13. Garden hose	10 roll @ 1800/roll	18,000
14. Basket	25pcs @150/basket	3,750
15. Wire (for roof)	1kg @ 150/kg	150
16. Plastic sheet (roofing)	15 kg @ 200/kg	3,000
Sub-Total		**83,000**
C.Tools and Equipment		Depreciation Cost
17. Knapsack sprayer	2 units @ 2,500/unit	500.00
18. Rake	5 pcs @ 250/pc	125.00
19. Grab hoe with handle	8 pcs @ 350/pc	280.00
20. Shovel	3 pcs @ 650/pc	190.00
21. Cythe	8 pcs @ 1175/pc	140.00
22. Trowel	8 pcs @ 175/pc	140.00
23. Knife	5 pcs @ 50/pc	25.00
Sub-Total		**1,400**
D. Land rent, 10,000.00 sq.m.@ 25,000/3 months		**25,000**
Total Cost of Production		**177,500**

*Modified from cost and return analysis of major commodities for farm diversification (1990).

Cost of labor, inputs and equipment were based on 2015 prices.

Treatments	Production Cost	Yield (tons/ha)	Less 10% spoilage & price fluctuation (Php25/kg)	Gross Income	Net Income	ROI (%)
No mulch	171,500	9.31	8.37	209,250	37,750	22.01
Fern	177,500	15.85	14,270	356,750	179,250	100.98
Sunflower		19.43	17,490	437,250	259,750	146.33
Alnus		17.19	15,470	386,750	209,250	117.88
Grasses		16.00	14,400	361,000	183,500	103.38