BIBLIOGRAPHY

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ABSTRACT

The study was conducted to identify the potato varieties that best respond to different rates of *Mokusaku*; determine the effects of different rates of *Mokusaku* to the growth and yield of the potato varieties; determine the interaction effect between rates of *Mokusaku* and potato varieties; and determine the profitability of producing the different potato varieties applied with *Mokusaku*.

The different *Mokusaku* rates had no significant effect on plant survival, plant height, canopy cover, tuber weight, dry matter and sugar content.

Among the four potato varieties, Solibao was the most resistant to late blight and had the highest marketable and total tubers yield.

No interaction effect between the rates of *Mokusaku* and potato varieties was observed on most of the parameters gathered.

In terms of economic returns, Solibao and Igorota not applied with *Mokusaku* obtained a high ROCE under organic production in La Trinidad.

INTRODUCTION

Potato (*Solanum tuberosum*) is well known worldwide as the fourth largest food crop in terms of fresh produce, after rice, wheat and corn. It is purposely for cash and eaten in many ways. It is a major source of starch as well as amino acids, protein and vitamins C, and B (Martin *et al*., 1976). Starch is the predominant form of carbohydrate in potatoes. Starch, like fiber, is also considered to have similar physiological effects and health benefits such as protection against colon cancer, improved glucose tolerance and insulin sensitivity, lower plasma cholesterol and triglyceride concentrations, increased satiety, and possibly even reduced fat storage (PCARRD, 2009).

In the Philippines, potato is consumed as a vegetable rather than staple and occasionally as a snack item. It is frequently cooked as a meat extender in recipes such as "adobo", "egado", curry, and "lumpia" (PCARRD, 2009).

As a result of population pressure, arable land is decreasing therefore there is a need to increase production per unit area. Potato being a heavy feeder of plant nutrients in the soil requires high supply of external mineral nutrients in the form of inorganic fertilizers or organic manure. However, decline in soil fertility and high costs of inorganic fertilizers are limitations to potato yield improvement in many production sites (Hughes and Metcalfe, 1972). Heavy use of commercial fertilizers also contributed to soil degradation and pollution.

Hence, there is a need to shift from chemical-based to organic-based production system for potatoes that is more sustainable.

Organic production reduce the exposure of the farmer to hazardous chemicals and favor the maintenance of the environment (Otculan *et al*., 2012). Furthermore, potato tubers are safe for consumption.

Lesser cost of production is also incurred in organic production systems, but lesser crop yield is also expected due to restricted use of farm inputs. However, market price of the produce is fixed at a reasonable price (Otculan *et al*., 2012) leading to higher profit.

One technology in organic systems is the use of wood vinegar or *Mokusaku* a technology from Japan. *Mokusaku* was introduced in Benguet as material to hasten composting process in just two months, improve the quality of the soil, and produce better quality of vegetables (Yokomori, 2012).

However, the use of wood vinegar here in Benguet is in its early stage. Thus, the application of wood vinegar to potato must be evaluated.

The result of the study will, therefore, serve as a guide to farmers who are engaged in potato production under organic system and lead them to choose the right varieties to increase their yield and to reduce the cost of production.

The study was conducted to:

1. identify the potato varieties that best respond to different rates of *Mokusaku*;
2. determine the effects of different rates of *Mokusaku* to the growth and yield of the potato varieties;
3. determine the interaction effect between rates of *Mokusaku* and potato varieties; and
4. determine the profitability of producing the different potato varieties applied with *Mokusaku*. The study was conducted from October 2012 to February 2013 at the Benguet State University Experimental Farm, La Trinidad, Benguet.

REVIEW OF LITERATURE

Philippine Potato Industry

White potato *(Solanum tuberosum L.)* ranks fourth among the world's major food crops and is the staple food of almost half of the world's population. Apparently, potato by-product is gaining much importance due to their high nutritive value and variety of uses. Potato production in 2006 was 69,461 tons (t) from 5,451 hectares (ha), with Benguet accounting for more than 60% of the total production. The other major producers are Davao del Sur, Mt Province, and Bukidnon. As production falls short of demand, especially in the processing types, the country imported US $ 36.4 million worth of potato products in 2006 (Bureau of Agricultural Statistics, 2006).

Potato Requirements and Physiology

Sarmiento (1995) stated that similar to the other crops, potatoes require proper nutrition to support plant growth and development. Its tubers are heavy feeders and continuous cropping in the same piece of land depletes soil fertility, making fertilization an indispensable activity.

To replenish soil nutrients, all growers apply either organic, inorganic or both types of fertilizers. In case of organic fertilization, all growers from barangays in Benguet and 49% of those in Barangays Kibenton and Songco in Bukidnon broadcast chicken manure before planting potatoes. This type of organic material is usually applied during land preparation (1-3 days before planting) to avoid direct contact of fresh organic materials with the seed tubers thereby preventing "burning" effects on the peel and its sprouts. Moreover, basal application allows thorough mixing of this fertilizer with the soil, hence, increased affectivity. Others, particularly the growers who use dried chicken manure, apply it during planting. Ideally, potato plants should be supplied with equal amounts of nitrogen (N), phosphorus (P) and potassium (K) at 140 kg each per hectare per cropping season.

Sarmient (1995) also stated that potatoes can be grown in the areas with cool climatic condition such as Davao del Sur. Research findings revealed that rainfall of 2.5 mm per week, evenly distributed throughout the growth period, is ideal for potato plants.

Utilization of Organic Fertilizers

When the organic residues are becoming soil or humus, they supply some of essential nutrients to plant, to serve as the principal source of nitrates, organic phosphate, organic sulfates, borates, and chloride, increase the cation exchange capacity; and make phosphorous and macronutrients more readily available to plants over a wide pH range. Organic residues release essential nutrients faster by microbial decomposition when their ration of organic carbon to total nitrogen is now wider than above 20:1 (Follet, 1991).

Koshino (1990) found that nutrient elements from organic fertilizers are released slowly which is particularly important in avoiding salt injury, ensuring a continuous supply of materials for the growing season, and producing product of better quality.

Use of Pyrolysis or *Mokusaku* Liquid as a Fungicide

Preliminary results of a laboratory experiment indicated that birch tar oil (10 and 30 % v/v aq solution) inhibited growth of wood rotting fungi (*Cylindrobasidium evolvens*, *Libertella sp.*, *Stereumhirsutum* and *Chondrostereum*) on Petri dishes (Tiilikkala and Segerstedt, 2009). The same effect was seen on the cut surfaces of birch branches treated with birch tar oil. In laboratory conditions, volatile components of birch tar oil effectively inhibited growth of potato late blight (*Phytophthora infestans*) fungi. A similar control effect was difficult to achieve outdoors when the same product was sprayed with conventional equipment (Tiilikkala and Segerstedt, 2009). Many control technologies have been developed to inhibit fungi that cause discoloration on timber. It has been shown (Velmurugan *et al*., 2009) that wood vinegar made from bamboo and broad-leaved trees are effective against sap staining fungi. The results revealed that compounds of *Chikusaku-eki* and *Mokusaku-eki* markedly inhibit fungal growth and the product possesses both antifungal and antioxidant properties as well as potential for useas a natural preservative in wood working industries. The antifungal efficiency of wood vinegars was reported to be strongly dependent on their phenolic compound content (Baimark and Niamsaa, 2009).

Nutrient Component and Description of *Mokusaku*

According to JAEC (2011), *Mokusaku* is liquid obtained from oil, juices, sap and other liquid contents of organic materials such as wood, coconut shell, bamboo, grass, and other plants after being heated in a chamber. The chamber is heated by burning firewood placed at the base of the chamber. When these organic materials are heated, their liquid contents evaporate as steam (gas, smoke). The steam passes through a tube (cooling chamber) where it will be allowed to cool. When the steam is cooled, the vapor will turn into liquid (condensation processed). The liquid is what is known as *Mokusaku*. From the tube, this liquid is collected in a container. *Mokusaku* is composed of a lot of organic chemical substances. Studies in Japan have shown that there could be 10 groups of organic chemical substances such as alcohol, ketone, carboxylic acid, furan, phenol, guaiacol, syringol, alkyl, phenol and others.

Beneficial Effects of *Mokusaku*

Yokomori (2012) aside from its use as a composting agent, *Mokusaku* is also effective as fungicide and insecticide. It also boosts the immune system of plants for them to be resistant to insects and control fungus such as grey and white molds. It is also used to control nematodes in the soil and it activates useful microorganisms and applies micronutrients needed for plant growth. *Mokusaku* is also a good supplement for health drinks. It helps in improving the digestive system especially for constipated people; makes the skin radiant; and removes hangover from drinking alcohol.

MATERIALS AND METHODS

An area of 240 m^2 was prepared for planting and divided into three blocks. Each block was composed of 16 plots with a dimension of 1 m x 5 m. The study was laid-out in Split Plot arranged in Randomized Complete Block Design (RCBD). The rate of *Mokusaku* served as main plot and the varieties of potato served as sub-plot.

Planting was done in double rows with 34 hills at a distance of 25 cm between hills and 30 cm between rows. After emergence, the potato plants were treated with different rates of *Mokusaku* up to the second week before harvesting. Spraying of *Mokusaku* was repeated every five days during the seedling period and twice a month during the growing and flowering period. *Bioganic,* an organic fertilizer composed of processed chicken manure and carbonized rice hull, was equally applied at a rate of 4 kg per plot. Upon crop establishment, all other practices for the successful production of potato including hilling-up, weeding and watering were equally employed in all the treatments.

The treatments were:

MAIN PLOT

F1= no *Mokusaku* applied

F2= 32 ml of *Mokusaku*/ 16 L of H_2O (recommended for potato)

F3= 24 ml of *Mokusaku*/ 16 L of H_2O

F4= 40 ml of *Mokusaku*/ 16 L of H_2O

SUB PLOT

V1= Granola

V2= Igorota (PO3)

V3= PO4 (Solibao)

V4= Raniag

<u>Data Gathered</u>

A. Agro meteorological data. The average daily rain fall (mm), sunshine duration (hours), average daily temperature (ºC) and relative humidity (%) were taken from the DOST-PAGASA Station at Barangay Balili, La Trinidad, Benguet.

B. Initial and final soil nutrient analysis. Soil samples were taken from the experimental area before planting and after harvest. The nitrogen, phosphorous, potassium (NPK), soil pH, and organic matter content of the soil were analyzed at the Department of Agriculture, Regional Field Unit 1, La Union.

C. Growth development. This was taken from randomly selected 10 plants.

1 Plant survival (%).This was taken at 30 days after planting (DAP) by using the formula below:

$$\text{Plant survival} = \frac{\text{Total number of plants survived}}{\text{Total number of plants grown}} \times 100$$

2. Plant vigor. This was taken by visual rating at 30, 45, 60 and 75 days after planting (DAP) using the CIP rating scale below (Gonzales *et al*., 2004):

Scale	Description	Remarks
1	Plants are weak; with few stems and leaves , very pale	Poor vigor
2	Plants are weak with thin stems and leaves, pale	Less vigorous
3	Better than less vigorous	Vigorous
4	Plants are moderately strong with robust stem and leaves; leaves are light green in color	Moderately vigorous
5	Plants are strong with robust stem and leaves; leaves are light to dark green in color	Highly vigorous

3. Initial height (cm). This was taken by measuring ten random sample plants per plot at 30 days after planting (DAP) from the base to the longest shoot.

4. Final height (cm). The plants were used in measuring the initial height was also used for final height. Plants are measured from the base up to the tip of the tallest shoot, one week before harvesting.

5. Canopy cover. This was taken at 30, 45,60 and 75 days after planting using a wooden frame measuring 120cm x 60cm and having a equally grid size of 12cm x 6cm. this was done by holding the frame over the foliage of representatives previously marked plants, grids will covered the effectives leaves are to be counted.

6. Leaf miner incidence. This was recorded at 30, 45, 60 and 75 days after planting by using the CIP rating scale (CIP, 2001):

SCALE	DESCRIPTION	REMARKS
1	Less than 20 % of plants per plot infected	Highly resistant
2	21-40 % of plants per plot infected	Moderately resistant
3	41-60 % of plants per plot infected	Susceptible
4	61- 80 % of plants per plot infected	Moderately susceptible
5	81-100 % of plants per pot infected	Very susceptible

7. Late blight incidence. This was gathered at 30, 45, 60 and 75 days after planting using the CIP rating scale (Henfling, 1987):

BLIGHT	SCALE	DESCRIPTION
0	1	No blight observed.
Traces -<5	2	Late blight present.
5-<15	3	Plans looks healthy, but lesions are easily seen at closer distance. Maximum foliage are affected by lesions or destroyed corresponds to more than 20 leaflets.

15-<35	4	Late blight easily seen on the most plants. About 25% of foliage is covered with lesions or destroyed.
35-<65	5	Plots looks green; however all plants are affected. Lower leaves are dead. About half the foliage of the plants destroyed.
65-<85	6	Plots look green with brown flecks. About 75% of each plant is affected. Leaves lower half of the plants destroyed.
85-<95	7	Plots neither predominantly green nor brown. Only top leaves are green. Many stems have large lesions.
95-<100	8	Plot is brown colored. A few leaves still have green areas. Most have lesions or are dead.
100	9	All leaves and stem are dead.

Description: 1 = highly resistant; 2-3 = resistant; 4-5 = moderately resistant; 6-7 = moderately susceptible; 8-9 = susceptible

8. <u>Weight of marketable tubers per plot (kg)</u>. The tubers that were not infected with disease and not damaged by insect and with 1% greening of the total surface area were considered and weighed per plot.

9. <u>Weight of non marketable tubers per plot (kg)</u>. The tubers which were infected with diseases, damaged by insect and malformed were considered as non-marketable tubers and were weighed per plot.

10. <u>Total weight per plot (kg)</u>. Marketable and non-marketable tubers in kilograms were summed up for total weight per plot.

11. <u>Dry matter content (%)</u>. Tubers were cubed and weighed into 100 grams per sample and dried at $80\ ^{o}C$ for 72 hours. Dry matter content was computed using the formula below:

% DMC= 100% - Moisture Content

Where:

$$\% \text{ Moisture Content (MC)} = \frac{\text{Fresh Weight} - \text{Oven Dry Weight}}{\text{Fresh Weight}} \times 100$$

12. Sugar content (°Brix). This was be taken by extracting the juice of 25 grams of potato tubers and was measured using a digital refractometer.

13. Computed yield per hectare (t/ha). This was taken by using the formula below:

$$\text{Computed yield (t/ha)} = \frac{\text{Total yield /plot (kg)}}{5\ m^2 /10000} \times 100$$

14. Return on cash expense (ROCE). Return on total cash expense was computed using the formula below:

$$\text{ROCE} = \frac{\text{Gross sales} - \text{total expenses}}{\text{Total expenses}} \times 100$$

RESULTS AND DISCUSSION

Meteorological Data

Table 1 shows the temperature, relative humidity, amount of rainfall and daily sunshine duration during the conduct of the study from October 2012 to January 2013. Minimum temperature ranged from 13.1 ^oC to 18.9 ^oC while maximum temperature ranges from 20.9 ^oC to 23.7 ^oC. The lowest relative humidity was noted in the month of November while the highest is in the month of January at 89%. The longest sunshine duration was noted in the month of December at 378 minutes while the shortest sunshine duration was noted in the month of October with 323 minutes. Rainfall amount ranged from 0.1 mm to 2.2 mm.

Potato grows best in areas with temperatures ranging from 17 ^oC to 22 ^oC with a mean of 19 ^oC and average relative humidity of 86%. Hence, the environmental condition in the site favors potato production and may even enhance better accumulation of carbohydrates and dry matter of the tubers (HARRDEC, 1996).

Table 1. The average daily temperature, relative humidity, rainfall amount, and sunshine duration from October 2012 to January 2013

MONTH	TEMPERATURE C^O			RELATIVE HUMIDITY (%)	RAINFALL AMOUNT (mm)	DAILY SUNSHINE DURATION (min)
	MIN	MAX	MEAN			
October	15.1	23.0	19.10	85.0	2.2	323
November	13.1	20.9	17.00	84.8	1.33	329
December	13.2	22.6	17.90	86.5	0.1	378
January	18.9	23.7	21.00	89.0	0.5	360
Mean	15.1	22.6	18.8	81.4	1.3	364

Source: Philippine Atmospheric Geophysical and Astronomical Services Administration (PAG-ASA), BSU, La Trinidad, Benguet

Nutrient Analysis of the Soil

pH. The initial pH of the area was slightly acidic (6.10). Increase in soil pH was observed in plots not applied with *Mokusaku* and applied with 32 ml *Mokusaku*. According to Chapman and Carter (1976), potatoes are well suited to acidic soil pH from 4.5 to 5.5.

Soil organic matter. Table 2 shows that application of *Mokusaku* is not effective for increasing organic matter of the soil except for application of 40 ml *Mokusaku.*

Nitrogen. The nitrogen content of the area was low which could be due to the N uptake by the crop. Researchers reported that potatoes need high amount of nitrogen for growth and development.

Phosphorous. There was a general increase in the total phosphorus content in the area. The increase may be due to the application of *Mokusaku* on the soil.

Potassium. There was an increase in the potassium content of the soil after harvesting. The increase may be due to the application of different rates of *Mokusaku*.

Table 2. The soil pH, organic matter, nitrogen, phosphorous, and potassium before and after harvesting

	pH	ORGANIC MATTER (%)	NITRO-GEN (%)	PHOSPHO-ROUS (ppm)	POTAS-SIUM (ppm)
Before planting	6.10	1.5	0.075	270	140
After harvesting					
no *Mokusaku*	6.17	1.5	0.075	380	243
32 ml of *Mokusaku*	6.13	1.5	0.075	373	255
24 ml of *Mokusaku*	6.10	1.5	0.075	350	387
40 ml of *Mokusaku*	6.10	1.7	0.085	413	259

Analyzed by the Regional Soils and Field Laboratory at San Fernando City, La Union

Plant Survival

Effect of *Mokusaku* rate. No significant differences were obtained on the percentage plant survival of potato applied with different rates of *Mokusaku*. Potato varieties applied with 40 ml of *Mokusaku* obtained the highest plant survival of 98% (Table 3).

Effect of potato variety. The potato varieties significantly differed in terms of percentage plant survival. Raniag and Igorota obtained the highest plant survival of 99.75 and 98.83%, respectively. The high percentage of plant survival could be due to desirable genetic characteristics or to the planting materials used.

Interaction effect. There was no significant interaction between the rates of *Mokusaku* and potato varieties on plant survival. This result implies that any of the potato varieties may not be applied with *Mokusaku* to have high plant survival.

Table 3. Plant survival of potato varieties applied with different rates of *Mokusaku*

TREATMENT	PLANT SURVIVAL (%)
Rate of *Mokusaku* (M)	
no *Mokusaku*	97.25
32 ml of *Mokusaku*	97.10
24 ml of *Mokusaku*	97.25
40 ml of *Mokusaku*	98.00
Potato Variety (V)	
Granola	96.00[b]
Igorota	98.83[a]
Solibao	95.00[b]
Raniag	99.75[a]
M x V	Ns
CV_a (%)	4.43
CV_b (%)	2.72

Means with the same letter are not significantly different at 5% level of DMRT.

Plant Vigor

Effect of *Mokusaku* rate. At 30 to 45 days after planting, the plant vigor of potato applied with *Mokusaku* was moderately vigorous but at 60 days after planting less vigorous plants were observed.

Effect of potato variety. Slight variations on plant vigor of the potato varieties at 30 to 45 days after planting were observed. At 60 days after planting, Granola, Igorota, and Raniag had poor vigor while Solibao remained vigorous.

Table 4. Plant vigor of potato varieties applied with different rates of *Mokusaku* at 30, 45 and 60 days after planting (DAP)

	PLANT VIGOR*		
TREATMENT	30DAP	45DAP	60DAP
Rate of *Mokusaku* (M)			
no *Mokusaku*	4	4	2
32 ml of *Mokusaku*	4	4	2
24 ml of *Mokusaku*	4	4	2
40 ml of *Mokusaku*	4	4	2
Potato Variety (V)			
Granola	4	4	1
Igorota	5	4	1
Solibao	4	5	3
Raniag	5	4	1

*Scale: 5 – Highly vigorous, 4 - Moderately vigorous, 3 – Vigorous, 2 – Less vigorous, 1– Poor vigor

Plant Height

Effect of *Mokusaku* rate. Plants applied with different *Mokusaku* rates had no significant differences in terms of plant height at 30 and 70 DAP (Table 5). However, it was observed that plants applied with 40 ml of *Mokusaku* produced the tallest plants.

Effect of potato variety. As shown in Table 5, Igorota significantly produced the tallest plants at 30 and 70 DAP. The significant differences on plant height could be due to their genetic characteristics.

Interaction effect. There was no significant interaction effect on plant height between potato varieties and different rates of *Mokusaku.*

Table 5. Initial and final height of four potato varieties applied by *Mokusaku*

TREATMENT	PLANT HEIGHT (cm) 30 DAP	70 DAP
Rate of *Mokusaku* (M)		
no *Mokusaku*	29.500	35.833
32 ml of *Mokusaku*	31.333	38.083
24 ml of *Mokusaku*	29.667	35.833
40 ml of *Mokusaku*	31.750	38.250
Potato Variety (V)		
Granola	23.917^{d}	24.083^{c}
Igorota	38.167^{a}	46.167^{a}
Solibao	27.167^{c}	32.667^{b}
Raniag	33.000^{b}	45.083^{a}
M x V	ns	ns
CV_a (%)	19.24	15.54
CV_b (%)	7.94	8.20

Means with the same letter are not significantly different at 5% level of DMRT.

Canopy Cover

Effect of *Mokusaku* rate. As shown in Table 6, there were no significant differences obtained in canopy cover of potatoes applied with different rates of *Mokusaku* at 30, 45, and 60 DAP. Widest canopy of plants was observed at 45 DAP, however plant canopy decreased at 60 DAP due to the emergence of late blight.

Effect of potato variety. There were significant differences observed on the canopy cover of four potato varieties applied with *Mokusaku* (Table 6). At 30 to 45 DAP, Igorota, Solibao and Raniag had the widest canopy. However at 60 DAP, only Solibao had the widest canopy which may imply high yield and resistance to late blight. All the other varieties were severely affected by the disease.

Interaction effects. No significant interaction between rate of *Mokusaku* and potato varieties was observed on canopy cover at 30 and 45 DAP. At 60 DAP, significant interaction between the two factors was observed. Solibao applied with 40 ml *Mokusaku* had the widest canopy (Figure 1).

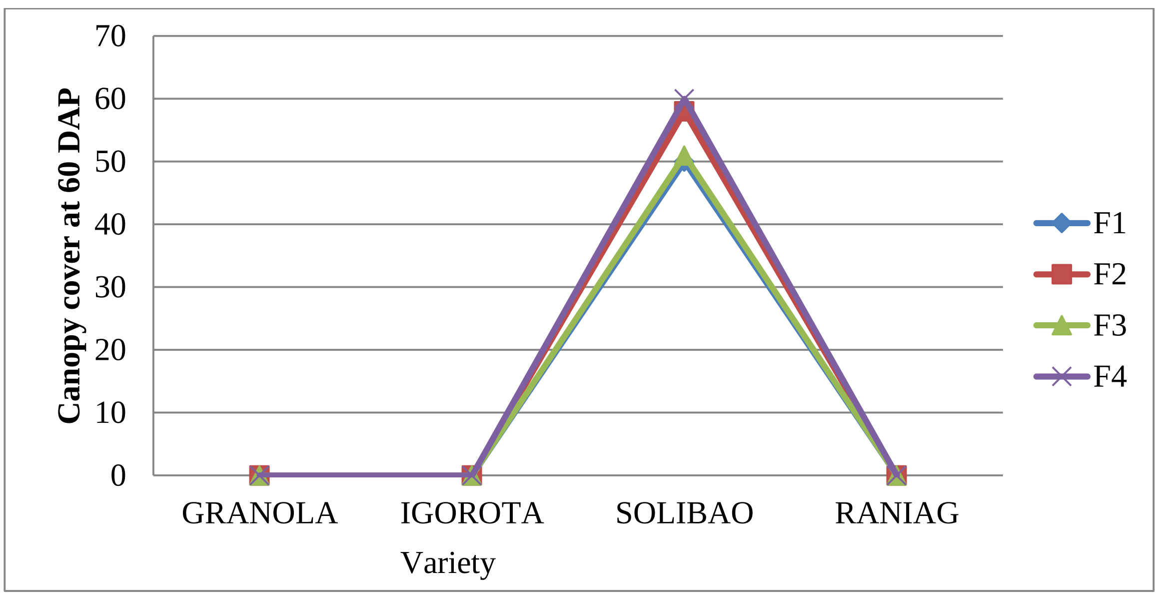

Figure 1. Interaction of potato varieties and *Mokusaku* rates on canopy cover at 60 DAP

Table 6. Canopy cover of potato varieties applied with different rates of *Mokusaku*

TREATMENT	CANOPY COVER 30 DAP	45 DAP	60 DAP
Rate of *Mokusaku* (M)			
no *Mokusaku*	42.67	51.42	12.58
32 ml of *Mokusaku*	50.08	53.75	14.42
24 ml of *Mokusaku*	40.67	51.08	12.75
40 ml of *Mokusaku*	44.75	54.75	15.08
Potato Variety (V)			
Granola	43.83[ab]	37.33[b]	00.00[b]
Igorota	47.83[a]	59.50[a]	00.00[b]
Solibao	39.75[b]	58.41[a]	54.83[a]
Raniag	46.75[a]	55.75[a]	00.00[b]
M x V	ns	ns	**
CV_a (%)	27.03	20.16	15.28
CV_b (%)	14.08	11.86	16.81

Means with the same letter are not significantly different at 5% level of DMRT.

Leaf Miner

Effect of *Mokusaku* rate. Table 7 shows the response to incidence of leaf miner of potato plants applied with *Mokusaku*. The plants which were not applied with *Mokusaku* and applied with different *Mokusaku* rates were highly resistant to leaf miner at 30 and 45 DAP. However at 60 DAP, symptoms of leaf miner infestation was not observed since most of the plants died due to late blight infection.

Effect of potato variety. The different potato varieties were highly resistant to moderately resistant to leaf miner at 30 to 45 DAP. However at 60 DAP, only Solibao remained moderately resistant while symptoms of leaf miner infestation was not observed in the other varieties that were severely infected with late blight.

Table 7. Response to leaf miner incidence of potato varieties applied with different rates of *Mokusaku*

TREATMENT	RESPONSE TO LEAF MINER INCIDENCE* 30DAP	45DAP	60DAP
Rate of *Mokusaku* (M)			
no *Mokusaku*	1	1	-
32 ml of *Mokusaku*	1	1	-
24 ml of *Mokusaku*	1	1	-
40 ml of *Mokusaku*	1	1	-
Potato Variety (V)			
Granola	1	1	-
Igorota	1	1	-
Solibao	1	2	2
Raniag	1	2	-

*Description: 1= highly resistant; 2= moderately resistant; 3= susceptible; 4= moderately susceptible; 5 =very susceptible

Late Blight

Effect of *Mokusaku* rate. Table 8 shows the response of potato plants applied with *Mokusaku* on late blight infection. The plants were highly resistant to late blight at 30 DAP while at 45 DAP, the plants were resistant. However at 60 DAP, the plants applied and not applied with *Mokusaku* were moderately susceptible to disease.

Effect of potato variety. High resistance to late blight was observed from Solibao at 30 to 45 DAP while the rest of varieties were resistant. At 60 DAP, most of the plants were susceptible to the disease (Figure 2) resulting in predominantly brown plants with necrotic spots. Only Solibao remained to be resistant to late blight. Occurrence of late blight may be attributed to scattered rainfall and high relative humidity in the month of January. According to Perez (2008), high relative humidity favors the occurrence of late blight.

Table 8. Response to late blight infection of potato varieties applied with different rates of *Mokusaku*

TREATMENT	RESPONSE TO LATE BLIGHT*		
	30DAP	45DAP	60DAP
Rate of *Mokusaku* (M)			
no *Mokusaku*	1	3	7
32 ml of *Mokusaku*	1	2	6
24 ml of *Mokusaku*	1	3	7
40 ml of *Mokusaku*	1	3	6
PotatoVariety (V)			
Granola	2	3	9
Igorota	1	3	8
Solibao	1	1	3
Raniag	1	3	7

*Description: 1 = highly resistant; 2-3 = resistant; 4-5 = moderately resistant; 6-7 = moderately susceptible; 8-9 = susceptible

Figure 2. Potato plants infected with late blight at 60 days after planting

Weight of Marketable and Non-marketable
Tubers per Plot

Effect of *Mokusaku* rate. The weight of marketable and non-marketable tubers of plants applied with different *Mokusaku* rates is presented in Table 9. No significant differences were observed, however, plants not applied with *Mokusaku* had the highest weight of marketable tubers.

Effect of potato variety. Table 9 shows significant differences in the weight of marketable tubers of four potato varieties (Figures 3 to 6). Solibao and Igorota had the heaviest marketable tubers which might be due to wide canopy cover and resistance to late blight. Slight variations and no significant differences were observed on the weight of non-marketable tubers among the potato varieties evaluated.

Interaction effect. The different rates of *Mokusaku* and potato varieties had no significant interaction on the weight of marketable and non-marketable tubers.

Table 9. Weight of marketable and non-marketable tubers of potato varieties applied with different rates of *Mokusaku*

	TUBER WEIGHT (kg/5m²)	
TREATMENT	MARKETABLE	NON-MARKETABLE
Rate of *Mokusaku* (M)		
no *Mokusaku*	3.00	0.46
32 ml of *Mokusaku*	2.88	0.52
24 ml of *Mokusaku*	2.66	0.43
40 ml of *Mokusaku*	2.54	0.58
PotatoVariety (V)		
Granola	2.48^{b}	0.48
Igorota	2.85^{ab}	0.62
Solibao	3.21^{a}	0.48
Raniag	2.54^{b}	0.41
M x V	ns	Ns
CV_a (%)	20.68	7.16
CV_b (%)	8.52	10.01

Means with the same letter are not significantly different at 5% level of DMRT.

GRANOLA

IGOROTA

SOLIBAO

RANIAG

Figure 3. Marketable tubers of four potato varieties not applied with *Mokusaku*

GRANOLA

IGOROTA

SOLIBAO

RANIAG

Figure 4. Marketable tubers of four potato varieties applied with 32 ml of *Mokusaku*

GRANOLA

IGOROTA

SOLIBAO

RANIAG

Figure 5. Marketable tubers of four potato varieties applied with 24 ml of *Mokusaku*

GRANOLA

IGOROTA

SOLIBAO

RANIAG

Figure 6. Marketable tubers of four potato varieties applied with 40 ml of *Mokusaku*

Total and Computed Yield

Effect of *Mokusaku* rate. There were no significant differences on the total and computed yield of potato varieties applied with different rates of *Mokusaku* (Table 10.).

Effect of potato variety. Highly significant differences were observed in the total and computed yield of potato varieties applied with *Mokusaku*. Solibao and Igorota significantly produced the highest total and computed yield which might be attributed to the heavy marketable and non-marketable tubers harvested.

Interaction Effect. The interaction between *Mokusaku* rates and potato varieties did not significantly affect the yield of potato.

Table 10. Total and computed yield of potato tubers applied with different rates of *Mokusaku*

TREATMENT	TOTAL YIELD ($kg/5m^2$)	COMPUTED YIELD (tons/ha)
Rate of *Mokusaku* (M)		
no *Mokusaku*	3.46	6.92
32 ml of *Mokusaku*	3.40	6.80
24 ml of *Mokusaku*	3.07	6.13
40 ml of *Mokusaku*	3.12	6.23
PotatoVariety (V)		
Granola	2.96^{b}	5.92^{b}
Igorota	3.44^{a}	6.88^{a}
Solibao	3.69^{a}	7.38^{a}
Raniag	2.95^{b}	5.90^{b}
M x V	ns	Ns
CV_a (%)	18.48	19.45
CV_b (%)	7.12	8.13

Means with the same letter are not significantly different at 5% level of DMRT.

Dry Matter Content

Effect of *Mokusaku* rate. No significant differences were observed on the dry matter content of potato tubers applied with different rates of *Mokusaku* (Table 11).

Effect of potato variety. A highly significant difference was observed on the tuber dry matter content of the potato varieties. The tuber dry matter content of the different potato varieties ranged from 14.917 to 22.750%. Igorota and Solibao are suitable for processing since they have above 18% dry matter content (Table 11). Tubers with less than 18% dry matter content are seldom used for frozen processing because of poor texture in processing (Mosley, 2005). Dry matter content of the tubers is affected by genetic characteristics of the varieties but may also be affected by environmental factors.

Interaction effect. There was no significant interaction observed between *Mokusaku* rates and potato variety in terms of tuber dry matter content.

Sugar Content

Effect of *Mokusaku* rate. There was no significant difference observed on the sugar content of potato tubers applied with different rates of *Mokusaku* (Table 11.). Effect of potato variety. No significant differences were observed on the sugar content of the four potato varieties evaluated. Granola obtained the lowest sugar content (Table 11.). Low tuber sugar content is preferred for processing since it usually results to light colored fries (Simongo *et al.*, 2011).

Interaction effect. No interaction effect was observed between the *Mokusaku* rates and potato varieties in terms of tuber sugar content.

Table 11. Tuber dry matter and sugar content of potato varieties applied with different rates of *Mokusaku*

TREATMENT	DRY MATTER CONTENT (%)	SUGAR CONTENT (°Brix)
Rate of *Mokusaku* (M)		
no *Mokusaku*	18.42	3.20
32 ml of *Mokusaku*	18.25	3.17
24 ml of *Mokusaku*	17.83	3.16
40 ml of *Mokusaku*	18.00	3.23
PotatoVariety (V)		
Granola	16.17[c]	3.12
Igorota	18.67[b]	3.25
Solibao	22.75[a]	3.23
Raniag	14.92[d]	3.16
M x V	ns	Ns
CV_a (%)	4.69	3.58
CV_b (%)	5.65	4.52

Means with the same letter are not significantly different at 5% level of DMRT.

Return on Cash Expenses

The return on cash expense of potato varieties applied with different rates of *Mokusaku* is shown in Table 12. Generally high ROCE was obtained among the varieties due to the high price of organic potatoes. Solibao and Igorota not applied with *Mokusaku* had the highest ROCE of 290%. Similarly, Solibao applied with 32 ml, 24 ml and 40 ml of *Mokusaku* had the highest ROCE when compared to the other varieties applied with *Mokusaku*.

Table 12. Return on cash expenses (ROCE) of four potato varieties applied with different rates of *Mokusaku*

TREATMENT	COSTOF PRODUCTION (Php)	MARKETABLE TUBER YIED (kg/15m^2)	GROSS SALES (Php)	NET INCOME (Php)	ROCE (%)
No *Mokusaku*					
Granola	154.00	8	480.00	326.00	212
Igorota	154.00	10	600.00	446.00	290
Solibao	154.00	10	600.00	446.00	290
Raniag	154.00	8	480.00	326.00	212
32 ml of *Mokusaku*					
Granola	159.00	7	420.00	261.00	164
Igorota	159.00	9	550.00	381.00	240
Solibao	159.00	10	600.00	441.00	277
Raniag	159.00	9	540.00	381.00	240
24 ml of *Mokusaku*					
Granola	158.00	7	420.00	262.00	166
Igorota	158.00	8	480.00	322.00	204
Solibao	158.00	10	600.00	442.00	280
Raniag	158.00	7	420.00	262.00	166
40 ml of *Mokusaku*					
Granola	160.00	8	480	320	200
Igorota	160.00	7	420	260	163
Solibao	160.00	9	540	380	238
Raniag	160.00	6	360	200	125

*Tubers were sold at Php 60.00 per kg.
*Total cost of production include *Mokusaku*, planting materials and labor

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Summary

The study was conducted at Balili, La Trinidad, Benguet from October 2012 to January 2013. The objectives are to identify the potato varieties that best respond to different rates of *Mokusaku*; determine the effects of different rates of *Mokusaku* to the growth and yield of the potato varieties; determine the interaction effect between rates of *Mokusaku* and potato varieties; and determine the profitability of producing the different potato varieties applied with *Mokusaku*.

Findings revealed that potato applied with different *Mokusaku* rates did not differ significantly on plant survival, plant height, plant vigor, response to leaf miner and late blight, and tuber yield.

The different potato varieties significantly differed on plant survival, height, response to leaf miner and late blight, canopy cover, weight of marketable tubers, total and computed yield. Solibao was the best performer in terms of resistance to late blight, yield and ROCE. The interaction between potato varieties and different rates of *Mokusaku* was significant in terms of canopy cover at 60 DAP.

Conclusions

Based on the results, the different rates of *Mokusaku* had no significant effect on leaf miner and late blight resistance, yield, and profitability of the potato plants.

Among the varieties, Solibao was the best in terms of resistance to leaf miner and late blight, high marketable tuber weight, total and computed yield, and profit. Igorota had also relatively high yield and profit in spite of its susceptibility to late blight.

Recommendations

Based on the results of the study, Solibao and Igorota are recommended for organic production under La Trinidad, Benguet condition due to high yield, resistance to pest, and profitability.

Further studies on application of *Mokusaku* using higher rates and different methods of application may be done.

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