BIBLIOGRAPHY

MAPANAO, JULIET D. APRIL 2013. Yield and Chip Quality of potato *var Igorota* Applied with different Volumes of Water under La Trinidad, Benguet Condition. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study aimed to determine the growth and yield of potato applied with different volumes of water, to determine the chip quality of potato applied with different volumes of water, and to determine the best water volume for maximum yield and chip quality of potato *var Igorota.*

Generally, no significant differences were observed in all the data gathered except for percent survival and dry matter content. The application of 200, 400 and 800ml significantly produced high percent survival comparable to the control of 600ml. The heaviest marketable yield was obtained from the application of 600ml (control) while the heaviest total yield was obtained from the application of 800ml water.

The lowest sugar and dry matter contents were obtained from the potato plants applied with 1000ml water. Whereas, 600 ml application gave the highest dry matter content.

The application of 200, 400, and 600 ml resulted in a crispy, slightly oily to not oily, perceptible, and liked much potato chips by the panelists.

INTRODUCTION

Potato (*Solanum tuberosum L.*) is one of mankind's valuable foods and is produced in 130 countries where three-fourths of the world's populations live. In addition, the best quality and largest yields are produced under cool climate and high altitude with elevations higher than 2000 meters such as Benguet and Mountain Province (HARRDEC, 1996).Thus, Benguet and Mountain Province are producing 74% of the Philippine potato production while the remaining percentage is produced from Mindanao.

Consumption of potato and potato by-products is growing rapidly in the Philippines. This scenario alone projects the increase in the demand of processing varieties considering the rising number of fast food chains and snack house like Jollibee and McDonalds coupled with the increasing population.

However, most of the potatoes grown like granola variety are not suitable for processing due to their inherent excessive moisture and sugar content. To address this problem, the Philippine government imported 61,699 metric tons of a wide range of processed potato products (PCARRD, 2008). The importation cannot compensate all the demands and needs of the country and it is just a short-term solution to the problem leading to the evaluations of different potato cultivars by researchers of the different agencies and institutions. These evaluations led to selection of several processing varieties and *Igorota* variety is one. The *Igorota* variety is one of the varieties developed at Benguet State University possessing a high dry matter content of 18-21% suitable for processing.

On the other hand, with the arising problem in climate change, FAO (2002) reported that agriculture is one of the most vulnerable sectors. Thus, food production and security will be most affected. It is stated that most agricultural regions experience periods of deficient moisture. It is reported that the prolonged drought of five to six months is common in the northern highlands of the Philippines like Benguet and Mountain Province. In these areas, potato as one of the major crops planted with a total 10, 960 hectares cultivated with potato annually (DA-CAR, 2005). Further, Jose (2008) stated that Benguet alone is planting 10,240 hectares planted yearly with crop often suffers from lack of irrigation during dry season.

To alleviate this problem, researchers have been working on the development of high yielding varieties with resistance to abiotic stresses such as drought or the development of drought tolerant genotypes.

Increased production of processing varieties is greatly needed due to the rising demand of the processing companies and the ever-increasing population. In fact, fast food chains particularly McDonalds and Jollibee, serving French fries in Baguio and La Trinidad alone need at least 2,000 to 6,000 kilos a week of potato suitable for French fries (Palangchao, 2009).

This demand however, cannot be attained because of some abiotic factors particularly drought or scarce water supply during summer in the rain-fed areas that contribute to low production. In addition to this, the poor and scarce water is a problem of vegetable farmers in the region, particularly Benguet. The scarcity of water in Benguet during the dry season results to less extensive production of food crops. On the other hand, with climate change, continuous rainfall is also being experienced in the growing area that causes flooding or above the saturation of the soil affects the growth and development of the potato. It is therefore necessary to determine the water use efficiency of potato for processing. Thus, the study evaluated the chip quality of *Igorota* applied with different volumes of water.

The objectives of the study were to:

1. determine the growth and yield of potato applied with different volumes of water;

2. determine the chip quality of potato applied with different volumes of water; and

3. identify the best water volume for maximum yield and chip quality of potato *var Igorota*.

The study was conducted from October 2012 to February 2013 at the Benguet State University Experimental Farm Station under a nethouse in Balili, La Trinidad, Benguet.

REVIEW OF LITERATURE

Demand of Processed Potato Product

In the Philippines, the demands for potatoes continue to increase because of the growing population, rise in the number of fast food chains and restaurants (Yano, 2009). Palangchao (2009) reported that McDonalds and Jollibee, serving French fries in Baguio and La Trinidad alone need at least 2,000 to 6,000 kilos a week of potato suitable for French fries. The demand of convenient foods such as chips and fries, to be particular, has led to the expansion of the potato industry (Garcia, 2006).

Distribution and Area of Production

Benguet and Mountain Province have a total of 10, 960 hectares planted with potato annually (DA-CAR, 2005), and Benguet alone is planting 10,240 hectares planted yearly which often suffer from lack of irrigation during dry season (Jose, 2008).

Potato Processing Quality

Chipping quality is genetically transmissible character. Potatoes that produced light-colored chips after cold storage and reconditioning were shown to transmit the ability to produce light- colored chips to their products (Oltmans and Novy, 2002).

For more processed products, a starch content of 13% or higher, a solid or dry matter content of 20% or higher, and specific gravity of 1.080 or higher is preferred (Stark *et al*., 2003).

Color is the most important factor in the evaluation of tubers for chipping. Hence, the yellow ones are the most preferred, whereas any other skin color may follow as long as it will pass the certain requirements of the processors (Sabiano, 2006). Similarly, Rastovski

(2003) added that yellow fresh color tubers are accepted not only for processing but also for table purposes. According to him, for more beta-carotene colored ones are preferred. In addition to this, potatoes with low reducing sugar content give an acceptable golden yellow chips which are acceptable for chipping industry.

Tuber size, shape, appearance, absence of disease or defects, flavor and texture all contribute to potato quality. Quality may be related to visual appeal, culinary preference of the consumer, or ability to match market specifications. Two of the most important quality characteristics of potatoes on the other hand, are starch content, which impacts cooked product texture, and sugar content, which has a direct bearing on fried product color (Stark *et al*., 2003).

Potato tuber characteristics such as shallow eyes, round or elongated tuber shape, smooth skin and freedom from defects are important characteristics because it requires lesser trimmings, provide preferred sizes, high chip yield, absence of discoloration or browning during frying and good quality. A study conducted, found out that shallow eye is one of the characters preferred by processors because there is less trimmings. Potatoes free from defects and disease are also considered whereas the round tubers are preferred for chips and the oval to elongated shape is otherwise preferred for French fries production (HARRDEC, 1996).

Specific Gravity and Dry Matter Content

Tuber specific gravity is the measure for estimating starch content and characterizing the processing potential of tubers. Low specific gravity potatoes, typically of red varieties for example, tend to be best for boiling and canning. Because specific gravity is related to maturity, tubers that have a longer time to accumulate car4bohydrates will generally have higher specific gravity than those with shorter growing periods. Therefore, early planting can increase the number of days that can potentially contribute to tuber starch deposition (Stark *et al*, 2003).

Numerous workers have shown that potato quality is directly associated with dry matter content. Specific gravity has been used as criterion of potato quality because of its close relationship to dry matter content and the rapidity with which it may be determined. High specific gravity potatoes are better suited for baking, frying, mashing, and chipping while, low specific gravity for boiling and canning. The potato chip manufacturers prefer potatoes of high specific gravity because they yield more chips per pound of potatoes. This outlet of potatoes is important in the potato industry at Hastings because over two million bushels of the annual crop are sold for chips (Mhyre, 1959).

High specific gravity is particularly important in the production of potato varieties for chips because of greater surface area to volume ratio and potatoes with high specific gravity are also preferred because they have been shown to absorb less oil during chipping process (Scanlon, 2006).

Water loss through transpiration is an inevitable cost of dry matter production, and there is about 200 to 800 g of water needed to produce a gram of dry matter for a range of climates. On the average, crop plants use 500 to 700 pounds of water to produce a single pound of dry matter. Thus, the required dry matter for the production of French fries should be containing 20 to 24 %. Higher or lower content of dry matter may give a negative result on the quality. A more mature potato usually has higher specific gravity or higher solid content and can be harvested with less skinning and bruising injuries (Smith, 1977).

Sugar and Starch Content

In the Processing Industry, accepted values for the reducing sugars are 0.2 % for chips and 0.5 % for French fries (Alingbas, 2007).

High starch content is favored by processors to ensure products have acceptable texture and to keep processing costs down by limiting the amount of raw product needed, the cooking time required and the amount of oil absorbed. Tuber sugar content on the other hand, has an important effect on the quality of processed products because of its large influence on fried potato color. When exposed to high levels of heat, which is typical of frying process, sugars combine with amino acids and other compounds to form dark color and flavor we associate with 'burned' food. This process is known as "Maillard Reaction". The reducing sugars glucose and fructose create the most serious problems during frying because they are chemically reactive. Sucrose however, contributes too little dark color development but is the substrate for creating more reducing sugars under the right environmental and physiological conditions. Potatoes intended for chip production should have a reducing sugar level below 0.35 mg/g or 0.035% of fresh tuber weight. Potatoes for processing as French fries therefore, should have less than 1.2 mg/g or 0.12% of tuber fresh weight. Potatoes with higher values will usually show color problems after cooking (Stark *et al*., 2003).

Sugar content of potatoes is affected by climatic factors in a location, such as temperature during growth, minimal nutrition, and irrigation. It is determined by genotype and several pre and postharvest factors and as tubers begin to grow, they are low in starch and high in sugars. Near the end of vine growth, the tubers reach the point known as physiological maturity- when they achieve maximum dry matter content and minimum sugar content. Moreover, potatoes destined for making chips, French fries and other fried products, need to have low sugar content to avoid browning of the finished product (Kumar *et al*., 2004).

It is found that very low sugar content is apparently important to prevent darkening of chips. Sugar content should be below 2%. Potatoes of low sugar content result in a lighter color chips desired by consumers (Smith, 1977).

Tuber Shape

Tuber shape is more uniform between 60^{o} and 70^{o} F than at temperatures above or below this. Tubers grown at 50^{o} to 55^{o} F are more spherical compared with the oblong shape of the Russett Burbank and White Rose varieties. Russett Burbank tubers are extremely knobby and the White Rose is spindle –shaped when grown at 80 to 85^{o} F. There are also multiple developments on a single stolon. This is often observed in the field with low moisture and high soil temperatures prevailing (Smith, 1977).

Cultivar/Variety

A three-year variety trial of more than 20 varieties conducted, showed that *Donald, Remarka and Signal* are the only varieties which produced high yields with a dry matter content of 21 to 23% when grown in Buguias under deficient irrigation (Jose, 2008).

Using the right variety ensures high yield and better quality of produce. In planting, the first decision is to know the best variety that is adapted to the locality to have a profitable production (HARRDEC, 1996).A processing variety must have high dry matter and low sugar content. Such varieties often have higher chip yield, crispy and slightly oily crops (Alingbas, 2007).

Irrigation

Potato needs frequent irrigation for its good growth and yield. The yield is greatly influenced by timing, amount and frequency of irrigation applied. Soil moisture is probably the most important factor determining potato yield and quality. Irrigation increases potato tuber quantity. It is very sensitive against water stress in all growing seasons, in particular at the duration of tuber formation. There is a decrease in tuber yield, tuber quality, income, and marketing degree in the conditions of deficit irrigation. Even the decrease for the level of 10% in the optimum water treatment in the growing period could have caused a decrease in yield. It was reported that potato was more sensitive to water stress at the stolonization and tuberization stages than the bulking and tuber enlargement stages. In the tuber enlargement stage, water deficit could be applied with a slight decrease in yield (Kiziloghu *et al*., 2006).

Early studies have shown that water is the most important limiting factor for potato production and it is possible to increase production levels by well- scheduled irrigation programs throughout the growing season (Bojujelben *et al*., 2001).

Excessive and deficit soil water availability during the growing season normally has a substantial adverse effect on crop yield and quality. In irrigated agriculture, proper water application depth and timing relative to crop growth is paramount for optimum economic return and maximum water use efficiency (Erdem *et al*., 2006).

Since no irrigation system is perfectly uniform, application uniformity should be quantified in order to measure irrigation system efficiency, because an irrigation must continue long enough to adequately water plants receiving the least water. The scale of the uniformity measurement should be related to the soil volume water occupied by potato roots (Pereira and Shock, 2006).

It was reported that irrigation of potatoes reduced specific gravity of potatoes. In contrast to this, another study found out that it was increased with soil moisture where the specific gravity of irrigated tubers were from 0.0002 to 0.004 lower than those not irrigated. It is due because maturity is promoted and specific gravity is higher when potatoes have been grown in low to medium soil moisture than at high soil moisture (Smith, 1977).

Tuber market grade and stem-end fry color is improved by moderate stress before tuber initiation (Pereira and Shock, 2006).

Potatoes have a shallow root system that requires more frequent irrigation when compared to other crops. Extreme variations in irrigation management and nitrogen availability influence tuber yield, size, grade, external quality, and internal quality (Pereira and Shock, 2006).

Irrigation should be continued to as close to harvest as possible to obtain maximum yields. When the last irrigation was 7, 14, and 21 days before harvest, yields where progressively reduced, as much as 205 reductions followed when irrigation was stopped 21 days before harvest. Moreover, by irrigation twice a week with the water level maintained at land 5 inches in the furrow, infiltration rate for the 5-inch depth was 40% more than the 1-nch depth, but yield was decrease 17% by irrigating only once a week, the infiltration rate was doubled with no effect on yields. Moreover, timing of irrigation may be altered at various stages of growth. Excessively frequent irrigations are more harmful from time of first bloom than later in the season. Plants are better able to withstand high moisture tension levels when evaporative conditions are less severe (Smith, 1977).

Potato is one of the most important crops in the world. Due to its sparse and shallow root system, potato is very sensitive to water stress and tuber yield maybe considerably reduced by soil water deficits Therefore, irrigation is always needed for production of high yielding crops. But with the increasing shortage of water resources, optimization of irrigation management therefore is required in order to improve water use efficiency (Liu *et al*., 2005).

Because of the sensitivity of potato to water stress, most researched has been focused on avoiding deficiencies in soil water. Tuber yield responses to irrigation decrease with over-irrigation (Pereira and Shock, 2006).

Deficit irrigation is a strategy which allows a crop to sustain some degree of water deficit in order to reduce irrigation costs and potentially increase revenues (Shock and Feibert, 2003).

During drought stress cycles, water savings under carbon dioxide allowed photosynthesis to continue for one to two days compared to ambient carbon dioxide treatment (Baker and Aller, 2005).

Water stress during early tuber bulking reduces specific gravity and increases reducing sugars associated with dark stem-end fry color (Shock and Feibert, 2003).

Water stress imposed from tuber initiation until the end of tuber bulking was the most detrimental to biomass and tuber production. Water stress imposed from tuber initiation until the end of tuber bulking storage and between emergence and tuber initiation stage produces the lowest yield (Steyn *et al*., 2003).

Water stress which occurs before tuber bulking, followed by resumption of irrigation may favor to occurrence of second growth since top growth is stimulated vigorously after a period of drought and high temperature (Van Loon, 1981).

Potato should be irrigated as even as possible, particularly at four to nine weeks after emergence when the tubers are forming to avoid tuber skin cracking and malformation (Ferreria and Carr, 2002).

Water Use Efficiency in Potato

Potato is one of the most important crops in the world. The increasing worldwide shortage of water resources then, requires optimization of irrigation management in order to improve water use efficiency (WUE).The term water use- efficiency describes a plant's photosynthetic production rate relative to the rate at which it transpires water to the atmosphere. It is a measure of plant performance that has long been of interest to agronomists, foresters, and ecologists. Among the irrigation regimens, the highest water use efficiency was generally obtained from application of irrigation when 30% of the available water was consumed. In addition to this, a study conducted to assess water use efficiency rate from different irrigation methods found out that drip irrigation method yielded higher values of WUE than furrow irrigation, since drip irrigation consumed less water (Erdem *et al*., 2006).

Water Resources

Seemingly abundant, water in the country is now becoming a scarce resource. A study on water resource accounting done in 1988 to 1994 by the environmental and Natural Resource Accounting-Integration Environment Management for Sustainable Development

Program (ENRA-IESMDP) showed that the stock of surface water has been decreasing t an average rate of 37%, while stock of groundwater has been decreasing at an average of 1.4 %. The diminishing stock can be attributed to the lower recharge rates compared to the rates of abstraction for both types of water resources. In 2001, NIA's irrigation systems (national and communal irrigation systems) as well as private irrigation systems, served only 44% of the potential, irrigable area, signaling an apparent water shortage especially during the dry season (PCARRD-DOST, 2003).

Political constraints, rising costs, and groundwater scarcities are resulting in less water available for agriculture. In some areas, groundwater supplies are being exhausted. Competition for world supplies is a worldwide phenomenon (Shock and Feibert, 2003).

Importance of Elevation to Potato Production

Potatoes are grown in higher elevations than other crops. In the tropics, the typical mountainous areas that produce potatoes is cold, best temperature fluctuated sharply from day to night and the average relative humidity is high. Soils are well-drained that there is great variation in altitude, slopes, soil fertility and other environmental variables that influence yields. Production hazards like frost cause low yields in highland areas, where the chances of crop failures are great, farmers often economize to purchase inputs in order to minimize their financial risks (Alingbas, 2007).

MATERIALS AND METHODS

Potato tubers of the *Igorota* variety from the Northern Philippines Rootcrop Research and Training Center, Benguet State University (NPRCRTC-BSU) were used as planting materials. One tuber was planted in a pot measuring 12 inches diameter. This was replicated three times and laid out using Completely Randomized Design (CRD). All cultural management practices were strictly employed like weeding to avoid competition of both water and nutrients. The different volumes of water which served as treatment, was strictly implemented three days after planting and applied based on the treatment as follows:

Code	Treatment
W_1 (control)	600 ml of water applied twice a week (Farmer's Practice)
W_2	1000 ml of water applied twice a week starting from 3 days after planting until 2 weeks before harvest
W_3	800 ml of water applied twice a week starting from 3 days after planting until 2 weeks before harvest
W_4	400 ml of water applied twice a week starting from 3 days after planting until 2 weeks before harvest
W_5	200 ml of water applied twice a week starting from 3 days after planting until 2 weeks before harvest

Chipping quality was evaluated by treatment after harvesting.

Chipping of potato. The tubers were washed, peeled, and sliced into 1-1.5 mm. The sliced tubers were again washed with tap water to remove the starch adhering to the slices. The slices were then wiped with clean cloth to remove excess moisture and fried in hot oil until bubbles are few (NPRCRTC, 1998).


a.) Washing


b.) Peeling


d.) Washing of chipped potato

c.) Chipping/ slicing


e.) Pat drying

F.) Frying

Figure 1. Chipping of potato tubers applied with different volumes of water

Data Gathered

1. Meteorological data. Temperature and relative humidity were taken using a digital hygrometer. Light intensity was recorded using a digital light meter.

2. Percent survival. Percent survival was taken at 30 DAP by counting the number of plants that survived and computed using the formula:

Percent Survival= No. of plants planted/ No. of plants that survived x 100

3. Plant vigor. This was taken at 30, 45, and 60 DAP using the following rating scale (Palomar and Sanico, 1994):

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

4. Pest and disease incidence. The crop was rated during the different growth stages using the following rating scales:

a. <u>Late blight incidence</u>. Late blight was rated using the following CIP rating scales (Henfling, 1981):

CIP Scale value	Blight Mean	% Limit	Symptoms
1	0		No late blight observable.
2	2.5	Traces-<5	Late blight present. Maximum of 19 lesions per plant.
3	10	5-<15	Plants look healthy, but lesions are easily seen at closer distance. Maximum foliage are affected by lesions or destroyed corresponds to no more than 20 leaflets.
4	25	15-<35	Late blight easily seen on most plants about 25% foliage is covered with lesions or destroyed.
5	50	35-<65	Plot looks green; however, all plants are affected. Lower leaves are dead. About half the foliage area is destroyed.
6	75	65-<85	Plot looks green with brown flecks. About 75% of each plant is affected. Leaves of the lower half of plants are destroyed.
7	90	85-<95	Plot neither predominantly green nor brown. Only top leaves are green. Many stems have large lesions.
8	97.5	95-<100	Plot is brown- colored. A few top leaves still have some green areas. Most stems have or are dead.
9	100		All leaves and stems dead.

b. Leaf miner incidence. The appearance of insect pest was observed during the growth stages at 30, 45, and 60 days after planting using the following scales (CIP, 2001):

Scale	Description	Reaction
1	Less than 20% of plants per plot infested	Highly resistant
2	21-41% of plants per plot infested	Moderately resistant
3	41-60% of plants per plot infested	Susceptible
4	61-80% of plants per plot infested	Moderately susceptible
5	80-100% of plants per plot infested	Very susceptible

5. Yield Parameters.

a. Marketable Yield (g/pot). During harvest, quality tubers were weighed.

b. Non-marketable Yield (g/pot). Tubers that were cracked, greened, and marble sizes were separated and weighed at harvest.

c. Total Yield (g/pot). The summation of marketable and non-marketable yield after harvest was taken.

6.Percentage Dry Matter and Moisture Content (%).This was taken by slicing thinly tubers into very small cubes taken from different treatments and oven dried 90g of sliced potato tubers for 48 hours at 100°C. It was taken using the following formula.

Moisture Content= Fresh weight –Oven dry weight/ Fresh Weight x 100

Dry Matter Content (%)= 100%− % Moisture Content

7. Sugar Content (^{o}Brix). This was taken by extracting the juice of 20g of potato tubers and measured by the use of a refractometer.

8. Sensory Acceptability of Chips. Sensory test was done by 10 untrained panelists composed of agronomy major students and faculty members and evaluated the chips using the following parameters (McDonald's, 1986).

a. Crispness

Scale	Description	Remarks
1	Very crispy	Very easy to crumble
2	Crispy	Easy to crumble
3	Moderately crispy	Crumbled without difficulty

b. Flavor Acceptability

Scale	Description	Remarks
1	Very perceptible	Very strong flavor
2	Perceptible	Strong flavor
3	Moderately perceptible	Little flavor
4	Slightly perceptible	Very little flavor
5	Not perceptible	No flavor

c. Oiliness

Scale	Remarks
1	Not oily
2	Slightly oily
3	Moderately oily
4	Oily
5	Very oily

d. General Acceptability

Scale	Remarks
1	Like very much
2	Like much
3	Like moderately
4	Like slightly
5	Not like/dislike

Data Analysis

All quantitative data were analyzed using Analysis of Variance (ANOVA) for Completely Randomized Design (CRD). Differences among treatment means were analyzed using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSIONS

Agro-meteorological Data

The temperature during the growing period range from 14°C to 29°C, relative humidity of 75% to 82% and light intensity of 1314fc to 1805 fc. The observed temperature range was above the requirement for potato production which greatly affected the yield. Mussell and Staples (1979) said that high temperatures are often associated with water stress. Also, Ferreria (2002) said that in hot dry climates or high temperatures, high evaporative demand increase crop water requirements which may compound the sensitivity of the crop to water stress resulting in greater yield reductions.

Driver and Hankes (1943) said that one of the physical component of the environment, temperature and its two extremes (heat and frost), has the capacity to reduce yields. They also suggested that excessive respiration due to high temperatures reduce the growth of tubers because of the decrease in the amount of available carbohydrates to be translocated to the underground parts. In addition, Borah and Milthorpe (1953) reported that a greater proportion of assimilates was used in stem, root, and stolon growth at 25°C than at lower temperature. This signifies that at lower temperature, the concentration of translocated carbohydrates at the stolon tip level was higher than at high temperature. Further, Mussel and Staples (1979) stated the interaction between physical (high temperature, excess and scarce moisture) and chemical (soil pH and nutrient supply) aggravates the biological factors such as diseases.

The relative humidity provides favorable condition for the growth of blight which contributed to the low yield. High relative humidity increases late blight incidence because of the presence of moisture that favors the occurrence of the disease (Tosay,

Table 1. Monthly temperature, relative humidity, and light intensity from October 2012 to January 2013

MONTH	TEMPERATURE (°C)		RELATIVE HUMIDITY (%)	LIGHT INTENSITY (fc)
	MIN	MAX		
October	17	29	80	1314
November	15	27	82	1758
December	14	29	75	1559
January	14	26	82	1805
MEAN	15	28	80	1609

2008). With regards to the high light intensity, Zaag (1992) reported that high light intensity is favorable for potato production for more efficient production of assimilates.

Percent Survival

There were significant differences among the different water volumes applied on the percent survival of potato plants (Table 2). The application of 200, 400 and 800ml water produced the highest percent plant survival but not significantly different with the application of 600ml. In contrast, plants applied with 1000ml water recorded the lowest with 71% survival. The low survival observed with the application of 1000 ml was because of the early infestation of bacterial wilt.

Plant Vigor at 30, 45, and 60 Days after Planting

Results showed that at 30 DAP, all treatments had highly vigorous plants (Table 2). This is maybe attributed to the genetic characteristics of the variety used because it was in consonance with what Daagdag and Tandang (2005) said that *Igorota* was preferred by farmers in Abra because of its uniform robust stems with good vigor. Generally, there was a noted decline in vigor at 45 to 60 DAP. Also, greater decline was observed in plants applied with the highest (1000ml) and lowest (200ml) volume of water. This means that high and low water application affects the yield because excess and little amount of water are not good in the growth of the plants. Vigor is affected primarily by the inherent characteristics, secondly is the environment including irrigation or moisture where the crop is grown (OSU, 1997).

Reaction to Late Blight

At 30 DAP, the data showed no infection in all the treatments, but a considerable change was noted at 45 to 60 DAP as shown in Table 3. During the later period of the study, greater variations were observed because the plants applied with 200, 400, and 1000 ml water were already severely infected implying susceptibility to the disease. This

Table 2. Percent survival and plant vigor at 45, and 60 DAP of potato plants applied with different volumes of water

WATER VOLUME	PERCENT SURVIVAL	PLANT VIGOR	
	%	45 DAP	60 DAP
600ml (control)	86[ab]	4	3
1000ml	71[b]	3	4
800ml	95[a]	3	5
400ml	91[a]	5	3
200ml	100[a]	4	5
CV (%)	2.43		

Means with the same letters are not significantly different at 5 % level of DMRT
Legend: 1-poor; 2-less vigor; 3-vigorou; 4- moderately vigorous; 5-highly vigorous

means that extremes, both high and low volumes favor the severity of the disease. According to Mussel and Staples (1979), it is due to the interaction between physical (high temperature, excess and scarce moisture) and chemical (soil pH and nutrient supply) aggravates the biological factors such as diseases considering that the variety used was moderately resistant to the disease (Shrestha, 1997). However, the prevailing condition during the study enhanced the occurrence of the disease that made the plants susceptible. According to Munns and Pearson (1995), high humidity and cool temperature are the major favorable conditions for the development of the disease. The agro-meteorological data showed that the prevailing weather during the conduct of the study favored the occurrence of the disease.

Table 3. Reaction to late blight at 45, and 60 days after planting of potato plants applied with different volumes of water

WATER VOLUME	REACTION TO LATE BLIGHT	
	45 DAP	60 DAP
600ml (control)	2	3
1000ml	3	5
800ml	2	3
400ml	2	3
200ml	3	5

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

Leafminer Incidence

Leaf miner incidence was taken at 30, 45, and 60 days after planting. During the entire study, all plants applied with different volumes of water are found to be highly resistant with less than 20% of the plants per pot infected.

Weight of Marketable, Non-marketable and Total Yield of Tuber

There were no significant differences on the weight of marketable tubers as shown in Table 4. Numerically, the data revealed that 600ml (control) of water produced the heaviest weight of marketable tubers and yielded the lowest weight of non-marketable tubers. The application of 1000ml of water in potato plants produced the lowest weight of marketable tubers while the plants applied with 800ml water had the heaviest weight of non-marketable tubers. Plants applied with 800ml water recorded the heaviest weight of total yield but also had the heaviest weight of non-marketable tubers. The plants subjected to1000ml irrigation had the lowest yield which is attributed to the low percent survival rate taken during the first month. The plants applied with water volumes above 400 ml excluding 1000ml had a better yield. According to Bawang (1981), limited soil moisture decreases number of tubers by 18-22%.

Percentage Dry Matter and Moisture Content

There were significant differences among the treatments as shown in Table 5 tubers irrigated with 1000ml water produced the lowest dry matter content of 18.28% whereas, 600 ml application gave the highest value of 23.07% comparable with plants applied with 200ml (22.86). Thus, 1000ml application is not advisable for processing variety like *Igorota* since high dry matter content is required while the control of 600ml water was the best volume to be applied because it was noted to have the highest dry matter content that suit the potato processing requirement. Stark *et al (2003)* stated that a value of 20% or higher is preferred for processing. Thus, the application of 400 and 800ml of water is also enough. Accordingly, Kellock (1995) said that a genetic characteristic of a crop however, excess of water during the growth of the plants will result to low dry matter content and Rastovski (2003) added that dry matter content is affected by genetic characteristics but maybe influenced by water uptake, photoperiod, and other factors. Further, Feltran (2004) found the same result that dry matter content is influenced by the conditions in the site.

<u>Sugar Content</u>

The sugar content of the tubers was not significantly different with each other (Table 5). Mean sugar content ranges from 3.3 to 3.5° Brix. The lowest was obtained from the potato plants applied with a volume of 1000ml water with a value of 3.3°Brix.

Table 4. Weight of marketable, non-marketable and total yield of potato tubers applied with different volumes of water

WATER VOLUME	YIELD (g)		
	MARKETABLE	NON-MARKETABLE	TOTAL
600 ml (control)	453	52	505
1000ml	256	67	312
800ml	425	111	536
400ml	368	70	438
200ml	354	50	404
CV (%)	5.67	19.64	27.45

Means with the same letters are not significantly different at 5% level using DMRT

Table 5. Dry matter and sugar content of potato plants applied with different volumes of water

WATER VOLUME	DRY MATTER CONTENT (%)	SUGAR CONTENT (°Brix)
600 ml (control)	23.07[a]	3.50
1000ml	18.68[c]	3.33
800ml	20.86[b]	3.53
400ml	21.35[b]	3.40
200ml	22.86[a]	3.53
CV (%)	9.33	3.42

Means with the same letters are not significantly different at 5% level using DMRT.

Moreover, all the treatments yielded good chips. The application of 1000ml volume registered the lowest sugar content. Findings of Stark *et al* (2003) showed that potatoes with higher values usually show color problems after cooking. Also, Feltran (2004) said that accessions with low sugar contents higher than 2% are unacceptable for frying however, there were cases when accessions with as high as 6.69^0 Brix were used for frying with no problems on chip quality. In 2007, Peet said that sugar content is a varietal characteristic that maybe influenced by environmental factors and this statement was corroborated with the results found by Kumar *et al* (2004) that sugar content of potatoes is affected by climatic factors in a location such as temperature during growth, minimal nutrition, and irrigation. Likewise, Nader and Heuer (1995) said that dry soil conditions in the later growth stages increases reducing sugar contents of the tubers.

Sensory Acceptability of Chips

Table 6 showed the results of the sensory acceptability of the chips. The potato chips from the application of 200, 400, and 600 ml had a crispy, slightly oily to not oily, perceptible, and liked much by the panelists. In contrast, 800 ml and 1000ml water volume applied to potato produced a moderately crispy, slightly oily to oily, perceptible, and liked much tubers by the evaluators. However, even 800ml water volume possessed moderately crispy and slightly oily chips, it could also be regarded as a potential volume for potato processing because it recorded an acceptable dry matter and low sugar content suitable for processing yielding. Further, 1000ml or excess irrigation is not advisable for potato processing production because it yielded chips that are not suitable for potato processing primarily because of its low dry matter content producing undesirable chip

Table 6. Sensory evaluation of the potato tubers applied with different volumes of water for chipping quality

WATER VOLUME	SENSORY CHARACTERISTICS			
	CRISPNESS	OILINESS	FLAVOR ACCEPTABILITY	GENERAL ACCEPTABILITY
600ml (control)	Crispy	Not oily	Perceptible	Liked much
1000ml	Moderately Crispy	Oily	Moderately Perceptible	Liked slightly
800ml	Moderately Crispy	Slightly oily	Perceptible	Liked much
400ml	Crispy	Slightly oily	Perceptible	Liked much
200ml	Crispy	Not oily	Perceptible	Liked much

characteristics. Feltran in 2004, said that crispness, oiliness, and texture are influenced by dry matter content. In addition, NIVAP (2007) found that varieties with high dry matter absorb less oil during chipping process.

600ml

1000ml

800ml

400ml

200ml

Figure 2. Chips of potato tubers applied with different volumes of water

600ml (control)

1000ml

800ml

400ml

200ml

Figure 3. Overview of the chopped potato tubers before oven drying for dry matter determination

SUMMARY, CONCLUSION, AND RECOMMENDATION

Summary

Yield and chip quality of potato *var Igorota* applied with different volumes of water was conducted at Balili, La Trinidad, Benguet under a nethouse condition from October 2012 to January 2013. The objectives of the study were to determine the growth and yield of potato applied with different volumes of water, determine the chip quality of potato applied with different volume of water, and to identify the best water volume for maximum yield and chip quality of potato *var Igorota.*

Generally, no significant differences were observed in all the data gathered except for percent survival and dry matter content. The application of 200, 400 and 800ml significantly produced high percent survival comparable to the control of 600ml. In the contrary, lowest was obtained from tubers applied with 1000ml water. The heaviest marketable yield was obtained from the application of 600ml (control) while the heaviest total yield was obtained from the application of 800ml water.

The lowest value of sugar and dry matter content was obtained from the potato plants applied with a volume of 1000ml water. Whereas, 600 ml application gave the highest dry matter content.

The application of 200, 400, and 600 ml had a crispy, slightly oily to not oily, perceptible, and liked much by the panelists.

Conclusion

Based on the findings, irrigation of 600 (farmer's practice) and 800 ml water are the best to potato plants in terms of yield and chip qualities based on survival, dry matter content, crispy, slightly to moderately oily, perceptible and liked much chips.

Recommendation

Based on the results of the study, it is recommended that the application of farmer's practice of 600 ml and 800 ml volumes of water for irrigation are the best volumes.

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