

EVALUATION OF PROMISING POTATO VARIETIES UNDER DIFFERENT ELEVATIONS

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ABSTRACT

The evaluation was conducted in different elevations at the Bureau of Plant Industry, Baguio City, Buguias, Bakun, Madaymen, Benguet and Mankayan, Mountain Province from December 2008 to March 2013 to evaluate yield performance, resistance to late blight disease and insect pests, and processing qualities, and recommend varieties to the National Seed Industry Council for commercial production and official release as recommended variety.

Variety Signal, Recolta and check Igorota significantly produced more vigorous plants, moderate to high resistance of late blight infection, and markedly low leafminer and aphid infestations. Significantly high yield of marketable tubers was obtained from Signal comparable with the check Igorota. Recolta produced marketable tubers excelling Farmer which was the lowest yielder. All varieties attained high dry matter content of tubers suitable for processing. Generally, sugar content was considerably low on Signal, Recolta and Igorota.

Varieties Signal and Recolta produced chips which were light yellow and free from discoloration, firm, very crispy and very perceptible. The chips taken from tubers of Farmer and Igorota had yellow, firm, very crispy, and very perceptible after frying.

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RATIONALE

Potato is one of the most nutritious and high value crops grown in the highlands. Its production is concentrated in Benguet and Mt. Province primarily due to cool climate favorable for its growth and development and production of premium quality tubers. It is cultivated mainly for its tubers which are consumed as fresh, cooked, processed or frozen products. Tubers of this crop contain high amounts of carbohydrates, proteins, minerals, and vitamins which may greatly contribute to minimize malnutrition problems in the country. Apart from its main use as a vegetable, it is being used as a condiment and in a limited scale for medicinal purposes as crude remedy for various ailments.

The crop is one of the priority commodities for commercial production in the highland region due to its high economic demand both local and export markets. Its economic value in table and processed product has increased tremendously for years. The establishment of fast food chains and processing companies in the country greatly contributed to the growing demand for varieties that can meet processing standard for French fries and chips. Despite an upward trend of production, the country is commonly confronted with inadequate supply resorting to importation of fresh and processed potato to meet local requirements. The economic impacts of such importation tremendously drain the country's revenue and dollar reserves.

Variety is the most important factor in obtaining high yield and better quality of produce. Selected varieties Signal, Recolta and Farmer are results of research and development efforts that exhibited consistent performance out of 15 genotypes tested in a series of field evaluations of Baguio National Crop Research and Development Center from 1998 to 2002. These varieties are high yielding, high in dry matter content with moderate resistance to late blight disease and potential for processing. Signal and Farmer were found specifically suitable for French fry while Recolta was identified acceptable for chips.

The increasing population and consequent need for more food including processed product has stimulated research and development undertakings to promote potato as a regular food crop in the Philippines, hence, the continuing screening of varieties for adaptability, resistance to pest and diseases, yield and quality.

Current varieties being grown commercially in the traditional high elevation potato producing areas of Benguet and Mt. Province is the result of long years of field trials. Variety Granola, Fina, Cosima and Berolina for example are the products of R & D efforts of the Philippine German Seed Potato Program under the Bureau of Plant Industry from 1977 to 1987. The latter three varieties are also found suitable under medium to low elevations when planted in the month of November to December (Taja et al, 1982).

Three processing varieties namely: Kennebec, Agria and Baraka were approved by the Philippine Seed Industry Council in December 1994 for commercialization (Castillo et al, 1994)

In 1982, Zaag revealed that quality is divided into external aspects such as shape and size of tuber, surface defects visible damage, and internal aspects such as dry matter content, sugar content, internal defects and diseases. These quality characteristics are governed by both the

variety and conditions under which the potato is grown. Tuber with high dry matter content is more floury and gave higher yields when processed into starch, instant mashed potato powder and chips with low sugar content is an important measure of quality and an indicator of mealiness used extensively by processors since yield of product is greater per unit fresh weight from tubers with a high solid content.

Coumou,(1982) stated that tubers for processing must have a size of 40 mm and 20% dry matter content for chips while 50 mm and above with 22% dry matter for French fries. Yang (1993) also stated that tubers with shallow eyes, long or oblong shape for adequate strips length and with average soluble solids contents of 21% or specific gravity of 1.081 are required by Mc Donalds Company. He further emphasized that dry matter content higher than 25% is no longer recommended because the resulting chips become too hard.

Tubers with at least less than 2% sugar content are recommended for processing (Beukema, 1989). High sugar content causes browning and low content results to lighter color. Browning is associated with the reaction of reducing sugar with amino acids during the frying process, as a result, dark brown substance are formed. He stressed that the best sensory qualities of chips are light yellow in color, slightly oily, crispy and very perceptible with good flavor and mealy inner texture.

OBJECTIVES

The selection of varieties in potato production for table and processing offers the opportunity to increase yield and improve quality. This study, therefore, aimed:

1. To evaluate the performance of promising potato varieties under different season and elevations.
2. To determine the processing qualities of the different potato varieties.
3. To recommend varieties to the National Seed Industry Council for commercial production.

METHODOLOGY

The trial was conducted in different elevations during the wet and dry seasons from 2008 to 2013. Three (3) selections from previous series of evaluations were utilized in all trial sites located in Baguio City, Buguias, Bakun and Madaymen, Benguet, and Mankayan, Mt. Province. Igorota (PO3) was used as control in all season and elevations. This variety is preferred by the farmers, high yielding with good processing quality, and highly resistant to late blight disease. Seed pieces of the varieties were produced by the Buguias Foundation Seedfarm of the Baguio National Crop Research and Development Center through positive selection of

healthy plants. Multiplied planting materials of these varieties were maintained and used for succeeding trials.

The different introduced varieties namely, Signal, Recolta and Farmer were originated from Holland and Igorota as locally developed variety was originated from the Philippines.

An experimental area measuring 200 square meter each per season and locations was thoroughly prepared by plowing or hoeing 2 times to achieve desired soil tilth. This was divided into 1.5 x 8 m-plot with each plot consisted of 2 rows in single row method of planting with 75 cm apart and a distance of 25 cm of seeds set between hills in the rows. Topography of the experimental sites were characterized as moderately flat to rolling terrain with sandy loam and silty clay loam type of soils, and crucifer crops preceding the experiment. The experiment was laid-out in a randomized complete block design (RCBD) replicated 4 times.

The selected sites for the study under different ecological zones or elevations were as follows:

Location	Elevation(masl)	Ecological zone (masl)
1. Buguias, Benguet	2,060	High mountain zone (2000 and above masl)
2. Bakun, Benguet	1,690	Mid-mountain zone (below 2000 masl)
3. Madaymen, Benguet	2,040	High mountain zone (2000 and above masl)
4. Mankayan, Mt. Province	1,900	Mid-mountain zone (below 2000 masl)
5. Baguio City	1,350	Low-mountain zone (1,350 masl)

In all trial sites, inorganic fertilizer (14-14-14) was applied basally at the rate of 150-150-150 kg/ha NPK mixed with 4 tons chicken manure which was applied one week before planting. All the required amount of fertilizer materials were mixed in the soil prior to planting. Further application of fertilizer was done whenever necessary.

Insecticides and fungicides were sprayed at weekly intervals following manufacturer's recommended rate mainly to control aphids, leaf miner and late blight disease. Cultural and management practices like manual weeding, hilling-up, watering, and other operations necessary for maintenance of growth and development were strictly followed throughout the growth duration of the test indicator varieties.

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

1. **Plant vigor.** This was evaluated 35 and 55 days after planting (DAP) using the rating scale as follows:

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

2. **Late blight disease rating.** This was assessed and taken at 35 and 55 days after planting by selecting 10 sample plants at random from each replication. The standard rating scale index developed by the International Potato Center was used as follows:

Scale	Percentage (%)	Description
1	0	Non or very few lesions
2	3	Less than 10% leaves with lesions
3	10	Less than 25% leaves with lesions
4	25	Less than 50% leaves with lesions
5	50	More than 50% of the leaves with lesions
6	75	75% of the leaves with lesions
7	90	90% of the leaves with lesions
8	97	Only few green areas much less than 10%
9	100	Leaves completely infected

3. **Aphid incidence.** Assessment of aphid was taken 35, and 55 days after planting using 1 - 9 rating scale index recommended by the Fertilizer and Pesticide Authority (FPA) as shown below

Rating Scale	Aphids presence in plants
1	no aphid present
3	few nymphs and adults present
5	several nymph present
7	colonies of aphids present
9	colonies are overlapping and plants are stunted

4. Leaf damage due to leafminer feeding (%). Although the population of larvae and adult leafminer was not determined the degree of damaged rendered through feeding manifested by the plants was assessed.

This was done 35 and 55 days after planting and determined following the 1-5 scale rating (after leafminer Task force, 1993).

Scale	Description
1	Sound, no leaves damaged
2	Slight, 1 to 15% of leaves damaged
3	Moderate, 11 to 25% of leaves damaged
4	Heavy, 26 to 50% of leaves damaged
5	Severe, more than 51% of leaves damaged

5. Yield Components. At harvest, the yield of tubers were classified according to sizes and the total marketable and non-marketable tubers were weighed separately and further computed to tons per hectare.

- a. **Marketable yield.** Tubers classified under extra-large, big, medium and small were considered marketable yields.
- b. **Non-marketable yield.** Tubers classified as marbles, diseased, physiologically disordered and rotten were considered non-marketable.

6. Dry matter content. This was evaluated by oven drying five sample tubers weighing 50-60 grams each at 70 to 80⁰C until constant for 2-3 days. Percent dry matter of tuber was determined using the equation below:

$$\text{Moisture content} = \frac{\text{Fresh weight} - \text{dry weight}}{\text{Fresh weight}} \times 100$$

$$\text{Dry matter content} = 100 - \text{moisture content (\%)}$$

7. Sugar content (°Brix). Sugar content of tubers was determined using a hand refractometer.

8. Chip quality. Quality was determined by color, texture, crispiness, and flavor after frying. Sample tubers weighing 500 gms from each variety were evaluated using the following criteria:

- a. **Color.** The chips were evaluated as brown, light brown, yellow and light yellow using the following scale developed by Mc. Donald Company

Scale	Description	Browning (%)
1	0	Excellent, no browning
2	1-2	Slight browning
3	3-4	Moderate browning
4	5 and above	Excessive browning

- b. **Texture.** This was evaluated using the following criteria:

Firm (Solid or compact and do not disintegrate)
 Soft (Smooth and easily shaped)
 Hard (Easily cut and punctured)

- c. **Crispiness.** Chips were evaluated using the following criteria:

Very crispy (very easy to crumble)
 Crispy (easy to crumble)
 Moderately crispy (crumble without difficulty)
 Slightly crispy (crumble with difficulty)
 Not crispy (hard to crumble)

- d. **Flavor.** Chips were evaluated based on perceptibility rating:

Very perceptible (very strong flavor)
 Perceptible (strong flavor)
 Moderately perceptible (little flavor)
 Slightly perceptible (very little flavor)
 No perceptible (no flavor)

9. Characterization. Morphology of each variety was characterized based on stem, leaf, mode of growth and maturity. On tubers, skin texture, depth of eyes and color of flesh were also evaluated and characterized.

RESULTS AND DISCUSSION

Plant vigor. Results obtained in Table 1a showed that variety Signal was significantly vigorous similar with the check variety Igorota more than the Farmer and Recolta which were comparable with each other almost in all season and elevations. Vigor of variety Recolta was markedly improved and insignificant with Signal and Igorota but different over Farmer during

November 2010 to March 2011 in Buguias. The mean vigor ratings of the different varieties ranging from 3.78 to 4.51 were moderate to highly vigorous in the scale.

In wet season of April to August 2010 (Table 1b), vigor of the varieties did not vary although higher ratings were recorded from Signal and Igorota than Farmer and Recolta. In 2012 of the same season in Baguio, Signal differed widely over Farmer, Recolta and Igorota respectively. While in Buguias, Signal and Igorota with similar ratings significantly excelled Recolta which was intermediate and Farmer with the lowest rating. Higher vigor of plants may mean increased photosynthetic efficiency essential for better growth and longer growing period which could result to higher yield and quality. Vigor ratings of variety Signal, Recolta and Igorota were generally higher than Farmer in all season and elevations reaching maximum levels equivalent to highly vigorous plants with strong and robust stems and leaves with light to dark green in color which may improve higher yields.

Table 1. Mean vigor rating of the potato varieties in different elevations.

a. Dry season set-up

Lines/Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	4.90	4.00 ^a	4.70	4.00 ^a	4.75 ^a	4.75 ^a	4.51 ^a
Farmer	4.00	3.50 ^b	4.50	3.50 ^c	4.00 ^b	3.75 ^b	3.78 ^b
Recolta	4.00	4.00 ^a	4.50	3.50 ^c	4.00 ^b	3.75 ^b	3.91 ^b
Igorota	4.50	4.25 ^a	4.75	4.00 ^a	5.00 ^a	4.87 ^a	4.48 ^a
CV%	31.00	5.00	9.00	5.00	19.00	18.00	12.00
ANOVA	n.s.	*	n.s.	*	*	*	*

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

Wet season set-up

Lines/Varieties	April – August 2011		April – August 2012		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	
Signal	5.00	4.75	5.00 ^a	5.00 ^a	4.95
Farmer	4.50	4.00	4.00 ^b	4.00 ^c	4.13
Recolta	4.50	4.50	4.25 ^b	4.55 ^b	4.45
Igorota	5.00	4.50	4.75 ^b	5.00 ^a	4.81
CV%	13.00	15.00	7.00	13.00	8.00
ANOVA	n.s.	n.s.	*	*	ns

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

Late blight incidence. Late blight assessments of the different varieties are presented in Table 2a, 2b and 2c. Variety Signal and Igorota were significantly resistant in late blight with incidence equivalent to less than 10% leaf infection (Table 2a). The incidence rating of variety Farmer was the highest with more than 50% or almost 75% of the leaves were infected while

variety Recolta was moderate with less than 25% of the leaves were infected. The relatively high infection of late blight during this season of December 2008 to April 2009 was brought about by the unusual occurrence of strong winds and monsoon rains with high relative humidity favoring the development of the disease.

In contrast, the rating indices of the different varieties generally decreased in the succeeding trials of November to March 2010 to 2013 dry season (Table 2b). Similarly, Igorota showed remarkably lesser infection identical to Signal with non or very few lesions and less than 10 % leaves with lesions compared to variety Farmer which was the highest with less than or close to 50% leaves with lesions. Blight rating was moderate in Recolta with infection equivalent to less than 25% with lesions. This indicates that variety Signal and check variety Igorota were highly resistant to late blight disease and conversely, variety Recolta was moderately resistant while Farmer was very susceptible. The susceptibility of the variety maybe attributed to the genetic characteristics and high relative humidity during the growing period that enhanced the invasion of the causal organism. The combined effect of rainfall, relative humidity and wind exerts significant effect over plant's resistance or may compensate or induce susceptibility to the disease.

Leaf blight indices of the different varieties taken in April to August 2011-2012 showed high rating from Farmer followed by Recolta. Signal consistently obtained lower infection ratings comparable with Igorota (Table 2c).

Under low elevation in Baguio, blight incidences of the different varieties were generally lower compared to mid-elevations in Bakun and Mankayan and high elevations in Buguias and Madaymen. The registered indices (Table 2a) except of variety Farmer (Table 2b) is equivalent to non or very few to about less than 10 % leaf infection. This result may be attributed to the low relative humidity of the area confirming the results taken from similar trials of 15 varieties conducted in 1998-2002.

Table 2. Mean late blight disease incidence on potato varieties in different elevations.

a. Dry season set-up

Lines/Varieties	December 2008 to April 2009				Mean
	Low Elev.	Mid Elev,	Mid Elev.	High Elev.	
	Baguio	Bakun	Mankayan	Madaymen	
Signal	1.25	2.25 ^c	3.65 ^c	3.00 ^c	2.54 ^c
Farmer	1.75	6.00 ^a	7.66 ^a	6.66 ^a	5.52 ^a
Recolta	1.75	3.75 ^{ab}	4.00 ^b	4.66 ^b	3.54 ^b
Igorota (check var.)	1.50	3.00 ^b	3.66 ^c	2.66 ^c	2.71 ^c
CV%	4.00	17.00	6.61	10.00	12.00
ANOVA	n.s.	**	**	*	*

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

b. Dry season set-up

Lines/Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	1.75 ^c	2.46 ^b	1.63	2.25 ^b	1.08 ^c	1.41 ^b	1.76 ^c
Farmer	4.0 ^a	3.80 ^a	2.87	4.90 ^a	5.25 ^a	4.12 ^a	4.16 ^a
Recolta	3.08 ^b	3.0 ^a	2.75	3.43 ^{ab}	3.5 ^b	2.25 ^a	3.00 ^b
Igorota	1.50 ^c	2.16 ^b	1.6	2.13 ^b	1.08 ^c	1.32 ^b	1.63 ^c
CV%	6.00	15.00	10.00	15.00	25.00	31.00	14.00
ANOVA	**	**	n.s.	**	**	**	**

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

c. Wet season set-up

Lines/Varieties	April – August 2011		April – August 2012		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	
Signal	2.50 ^b	2.75 ^c	2.00 ^d	2.80 ^c	2.51 ^c
Farmer	5.00 ^a	6.50 ^a	5.25 ^a	5.00 ^a	5.54 ^a
Recolta	4.50 ^a	4.00 ^b	4.20 ^b	4.00 ^b	4.18 ^b
Igorota	2.75 ^b	2.50 ^c	2.50 ^c	2.00 ^c	2.44 ^c
CV%	15.00	8.00	7.00	8.20	9.00
ANOVA	**	**	**	**	**

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

Leaf miner incidence. Table 3a showed that leafminer infestations were significantly lower in Signal but similar to the check variety Igorota. Significantly higher infestation was shown in Farmer and comparable with Recolta. The data obtained in December 2008 to April 2009 dry season ranging from 2.42 to 3.50 of leaves damaged was moderate and close to heavy leaf damage of 26 to 50% (Table 3a), contrary to indices during November to March 2010- 2013 ranging from 1.79 to 3.03 which were sound or no leaves damaged to only slight or 1 to 15 % of leaves damaged (Table 3b).

No significant differences were observed in the incidence of leaf miner among the different potato varieties during wet season evaluation from April to August 2011 to 2012 (Table 3c). The rating incidence that ranged slightly from 1.54 to 1.98 for all varieties indicates sound, no leaves damaged or near to slight with 1.0 to 15 % only of leaves damaged. Similar to blight infection, like the plants of Farmer and Recolta become very susceptible and moderately susceptible under different elevations especially during the dry season. This result may be attributed to warm weather due to climate change giving higher temperature that favored the presence and build up of the pest causing infestation and damage during the vegetative stage.

Table 3. Leafminer incidence on potato varieties in different elevations.

a. Dry Season set-up

Lines/Varieties	Dec 2008 to April 2009				Mean
	Low Elev.	Mid. Elev.	Mid. Elev.	High Elev.	
	Baguio	Bakun	Mankayan	Madaymen	
Signal	1.75 ^b	3.25 ^b	3.00 ^b	1.66	2.42 ^b
Farmer	3.25 ^a	4.00 ^a	4.00 ^a	2.33	3.40 ^a
Recolta	3.25 ^a	3.75 ^b	4.33 ^a	2.66	3.50 ^a
Igorota (check variety)	2.00 ^b	2.80 ^c	3.00 ^b	2.33	2.53 ^b
CV%	16	10.51	6.50	24.00	15.00
ANOVA	**	**	**	n.s	*

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

b. Dry Season set-up

Lines/Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	1.75 ^b	1.85 ^b	1.75 ^c	2.93 ^b	1.87	1.62	1.96 ^b
Farmer	2.50 ^a	3.60 ^a	4.43 ^a	3.87 ^a	2.50	1.25	3.03 ^a
Recolta	2.75 ^a	3.00 ^a	2.93 ^b	3.43 ^a	2.37	1.87	2.73 ^a
Igorota	1.50 ^b	1.75 ^b	1.62 ^c	2.12 ^b	2.00	1.75	1.79 ^b
CV%	5.45	4.19	7.00	24.00	28.00	20.00	10.00
ANOVA	**	**	**	**	n.s.	n.s.	**

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

c. Wet season set-up

Lines/Varieties	April – August 2011		April – August 2012		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	
Signal	1.85	1.62	1.00	1.00	1.74
Farmer	2.20	1.75	1.00	1.00	1.98
Recolta	2.02	1.50	1.00	1.00	1.76
Igorota	1.47	1.60	1.00	1.00	1.54
CV%	25	22.75	-	-	21.02
ANOVA	n.s.	n.s.	-	-	ns

Aphid incidence. Table 4a and 4b presents aphid incidence of the different potato varieties. In dry season November to March 2010- 2013 Variety Signal was found to be resistant to aphids the same with the check variety Igorota. The other varieties Recolta and Farmer were moderately resistant to the pests (Table 4a).

Incidence of aphids on varieties grown in high elevation of Buguias were lower than in low elevation of Baguio. The low incidence or no presence of aphids in Buguias could be due to relatively lower temperature, rainy and windy environment not suitable for the settlement of the pest and other insects. Moreover the difference on aphid infestation could be due to short spray frequency regime by the respective cooperators of the trial. The spray frequency of insecticide and fungicide in Buguias was 3-day interval while 7-day interval in Baguio.

During the wet season from April- August 2011 and 2012, no significant result was recorded, or no aphid infestation or presence as well as symptom of leaf damage due to feeding by aphids. The incidence rating recorded was 1.00 on all varieties in all season and elevations (Table 4b).

Table 4. Mean Aphid Incidence of potato varieties in different elevations.

a. Dry season set-up

Lines/Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	2.85	1.00	1.62 ^b	1.75 ^b	1.5	2.2	1.98 ^b
Farmer	3.25	1.00	2.42 ^a	1.50 ^a	2.25	2.0	2.28 ^a
Recolta	3.37	1.00	2.37 ^a	1.37 ^{ab}	2.12	2.0	2.25 ^a
Igorota	2.75	1.00	1.87 _b	1.12 ^{bc}	1.75	1.75	1.85 ^b
CV%	6.15	-	9	10	24	25	9.40
ANOVA	n.s.	n.s.	*	*	n.s.	n.s.	*

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

b. Wet season set-up

Lines/varieties	April – August 2011		April – August 2012		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	
Signal	1.00	1.00	1.00	1.00	1.00
Farmer	1.00	1.00	1.00	1.00	1.00
Recolta	1.00	1.00	1.00	1.00	1.00
Igorota	1.00	1.00	1.00	1.00	1.00
CV%	1.0	1.0	1.0	1.00	1.00
ANOVA	-	-	-	-	-

Weight of Marketable Tubers. Variety Signal was significantly highest in yield against the other varieties, however, similar with Igorota during dry season of December 2008 to April 2009 (Table 5a). Recolta was rated next, out yielding Farmer which had the lowest yield. In the dry season of November to March 2010 to 2013, Signal consistently produced higher yields

surpassing check variety Igorota (Table 5b). Variety Recolta similarly increased this over the variety Farmer with the lowest yield.

The same trend in yield was observed among the varieties during the wet season of April to August 2011 to 2012 (Table 5c). Variety Signal maintained its high yield outranking Igorota , while Recolta was moderate and Farmer was consistently the lowest.

Generally, the varieties produced higher weights of marketable tubers during the dry season than wet season due to favorable weather conditions prevailed in the different elevations. The significant yield obtained from Signal and Igorota together with Recolta may be attributed to their moderate to high resistance to late blight disease, leaf miner and aphids, and better vigor of plants. It was observed that the higher vigor and resistance to pests and disease exemplified by the varieties, the higher is the yield.

Table 5. Weight of marketable tubers (tons/ha) of potato varieties in different elevations

a. Dry season set-up

Lines/Varieties	Dec. 2008 to April 2009				Mean
	Low Elev.	High Elev.	Mid.Elev.	High Elev.	
	Baguio	Bakun	Mankayan	Madaymen	
Signal	18.83 ^a	18.30 ^a	15.20 ^a	17.67 ^a	17.56 ^a
Farmer	13.51 ^c	13.28 ^d	8.62 ^c	7.92 ^d	10.83 ^c
Recolta	16.05 ^b	15.70 ^c	12.30 ^b	13.36 ^c	14.35 ^b
Igorota (check variety)	18.50 ^a	18.66 ^a	15.60 ^a	17.66 ^a	17.61 ^a
CV%	6.84	2.48	4.30	8.60	9.00
ANOVA	**	**	**	*	*

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

b. Dry season set-up

Lines/ Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	20.49 ^a	19.86 ^a	21.72 ^a	18.50 ^a	19.16 ^a	20.74 ^a	20.09 ^a
Farmer	14.22 ^c	15.52 ^b	8.33 ^c	8.50 ^c	15.72 ^b	13.46 ^c	12.63 ^d
Recolta	17.65 ^b	15.85 ^b	18.37 ^b	13.15 ^b	17.54 ^{ab}	18.49 ^b	16.84 ^c
Igorota	19.71 ^a	16.64 ^b	21.74 ^a	18.47 ^a	18.32 ^a	18.00 ^b	18.81 ^b
CV%	6.29	4.45	13.00	8.00	27.00	24.00	18.00
ANOVA	**	**	**	**	**	**	**

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

c. Wet season set-up

Lines/ Varieties	April – August 2011		April – August 2012		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	
Signal	19.70 ^a	17.50 ^a	18.70 ^a	18.75 ^a	18.66 ^a
Farmer	10.50 ^d	9.50 ^d	12.13 ^c	10.25 ^d	10.60 ^d
Recolta	15.75 ^c	14.75 ^c	14.50 ^b	15.60 ^c	15.15 ^c
Igorota	18.20 ^b	16.00 ^b	18.50 ^a	17.50 ^b	17.55 ^b
CV%	12.00	8.00	15.00	9.00	11.00
ANOVA	**	**	**	**	**

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

Weight of non-marketable yield. Tables 6a, 6b and 6c shows no significant result of the different varieties in non-marketable yield of tubers. Nonetheless, slightly higher weights were observed in Farmer and Recolta than Signal and Igorota due to higher incidence of late blight caused by continuous rains, high relative humidity and occurrence of strong winds during the trial periods.

Table 6. Weight of non-marketable tubers (tons/ha) of potato varieties in different elevations.

a. Dry season set-up

Varieties	December 2008 – April 2009				Mean
	Low Elev.	Mid Elev.	Mid Elev.	High Elev.	
	Baguio	Bakun	Mankayan	Madaymen	
Signal	0.53	0.45	0.15	0.58	0.43
Farmer	0.65	0.50	0.02	0.05	0.31
Recolta	0.47	0.45	0.17	0.08	0.29
Igorota	0.41	0.49	0.12	0.05	0.26
CV%	3.13	3.13	1.08	8.00	3.80
ANOVA	n.s.	n.s.	n.s.	n.s.	n.s.

b. Dry season set-up

Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	0.30	0.45	0.30	0.45	0.55	0.42	0.36
Farmer	0.35	0.55	0.35	0.50	0.40	0.50	0.44
Recolta	0.37	0.47	0.37	0.45	0.35	0.45	0.41
Igorota	0.29	0.49	0.29	0.49	0.50	0.40	0.41
CV%	2.45	1.04	2.45	2.10	1.05	1.06	1.04
ANOVA	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

c. Wet season set-up

Lines/ Varieties	April – August 2011		April – August 2012		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	
Signal	0.85	0.85	1.56	1.50	1.19
Farmer	1.45	0.75	1.55	1.20	1.24
Recolta	1.43	1.36	1.58	1.55	1.48
Igorota	0.75	1.25	1.45	1.40	1.21
CV%	1.30	2.60	1.90	1.30	1.40
ANOVA	n.s.	n.s.	n.s.	n.s.	n.s.

Dry Matter Content. Table 7a, 7b, and 7c presents the dry matter content of the varieties in different season and elevations. During the dry season of December 2008 to April 2009, all the varieties exhibited high dry matter with an overall means ranging from 18.70 to 19.50 % which is acceptable for processing (Table 7a). Dry matter content in dry season from November to March 2010 to 2013 gave Farmer, Igorota and Recolta, with comparable averages of 22.54, 21.94 and 21.55 %, highly significant difference over that of Signal with 18.73 % (Table 7b).

In wet season of April to August 2011, dry matter content of the varieties was lower compared with the dry seasons (Table 7c). The check variety Igorota had the highest and differed widely over the rest of the varieties. Variety Recolta and Farmer which were comparable with each other significantly increased it more than the variety Signal. Low dry matter contents during wet season maybe due to high rainfall or excessive water resulting to low dry matter production in the potato tuber. All test varieties generally produced high dry matter content, and in most season and elevations were comparable with the check variety Igorota. The production of dry matter in tubers manifest that these varieties has the capacity to maintain or increase dry matter content. The average dry matter content of 18.00 to 22.00 % produced indicates that these varieties can be utilized for processing fries and chips. Tubers with less than 18.00 % dry matter are not suitable for processing because of undesirable color, hard texture, not crispy with poor flavor and perceptibility of chips.

Table 7. Percent(%) dry matter content of potato varieties in different elevations.

a. Dry season set-up

Lines/Varieties	December 2008 to April 2009				Mean
	Low Elev.	Mid Elev.	Mid Elev.	High Elev.	
	Baguio	Bakun	Mankayan	Madaymen	
	DMC	DMC	DMC	DMC	
Signal	18.00	19.00 ^a	19.00 ^b	22.00 ^a	19.50
Farmer	19.54	18.00 ^b	20.00 ^a	19.00 ^b	19.14
Recolta	18.78	18.00 ^b	19.00 ^b	19.00 ^b	18.70
Igorota (check variety)	19.05	19.50 ^c	19.00 ^b	19.50 ^b	19.26
CV%	8.76	11.19	3.56	5.07	7.15
ANOVA	n.s.	*	**	**	n.s.

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

b. Dry season set-up

Lines/Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
	Signal	18.22 ^c	18.13 ^b	18.22 ^c	18.13 ^c	20.95 ^a	
Farmer	24.01 ^a	23.02 ^a	24.10 ^a	23.03 ^a	20.10 ^a	20.95 ^a	22.54 ^a
Recolta	24.10 ^a	22.05 ^a	24.01 ^b	22.00 ^b	18.37 ^b	18.75 ^{bc}	21.55 ^a
Igorota	22.67 ^b	23.68 ^a	22.50 ^b	23.68 ^a	19.33 ^b	19.76 ^{ab}	21.94 ^a
CV%	4.93	7.49	5.00	13.00	23.00	23.00	12.74
ANOVA	**	**	**	**	**	**	*

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

c. Wet season set-up

Lines/Varieties	April – August 2011		Mean
	Low Elev.	High Elev.	
	Baguio	Buguias	
Signal	17.07 ^c	17.11 ^c	17.09 ^c
Farmer	19.90 ^b	20.00 ^a	19.95 ^b
Recolta	18.69 ^{bc}	18.00 ^b	18.35 ^{bc}
Igorota	21.34 ^a	20.65 ^a	21.00 ^a
CV%	30.00	9.00	9.60
ANOVA	**	**	**

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

Total Soluble Solid. Sugar content of the different varieties are recorded in Table 8a, 8b and 8c. These sugar contents did not vary among the varieties with low means ranging from 5.20 to 6.20 °Brix during November to April 2008 to 2009 dry season (Table 8a). Similar results were

obtained in the dry season of November to March 2010 to 2013 with an overall means ranging from 6.61 to 6.79 (Table 8b). Low sugar contents taken from the different varieties maybe attributed to the genetic characteristics of the varieties and influence of environmental factors in each season and elevations. Yamaguchi, et al. (1964), stated that sugar content is lower when grown at soil temperature between 15 and 24 °C than when grown at higher temperatures. During the wet season of April to August 2011, a non-significant result was also detected in all varieties from all season and elevations with sugar content ranging from 6.25 to 6.63 °Brix in the prescribed scale (Table 8c). Sugar content of tubers affects the color of chips and fries. Low sugar content results to lighter yellow color while high sugar content causes browning of chips and fries. The best sensory qualities of chips are light yellow in color, slightly oily, crispy and very perceptible.

Table 8. Total Soluble Solid (°Brix) of potato varieties in different elevations.

a. Dry season set-up

Varieties	December 2008 – April 2009				Mean
	Low Elev.	Mid Elev.	Mid Elev.	High Elev.	
	Baguio	Bakun	Mankayan	Madaymen	
Signal	5.20	5.00	5.20	5.20	5.15
Farmer	6.00	6.20	6.00	6.20	6.10
Recolta	5.50	5.00	5.20	5.20	5.22
Igorota	5.50	4.80	4.90	4.70	4.22
CV%	9.01	13.39	5.30	13.39	10.70
ANOVA	n.s.	n.s.	n.s.	n.s.	n.s.

a. Dry season set-up

Lines/Varieties	Nov.2010 – Mar.2011		Nov.2011 – Mar.2012		Nov.2012 – Mar.2013		Mean
	Low Elev.	High Elev.	Low Elev.	High Elev.	Low Elev.	High Elev.	
	Baguio	Buguias	Baguio	Buguias	Baguio	Buguias	
Signal	6.75	7.50	6.25 ^a	6.25	6.20 ^{5b}	6.50	6.75
Farmer	6.25	7.00	6.5 ^a	6.75	6.13 ^a	6.12	6.96
Recolta	6.75	7.25	6.25 ^b	6.50	6.63 ^{ab}	6.25	6.61
Igorota	6.75	7.00	6.25 ^a	6.75	6.25 ^b	6.73	6.79
CV%	9.00	5.98	10.00	13.00	15.00	12.00	10.83
ANOVA	n.s.	n.s.	*	n.s.	*	n.s.	n.s.

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

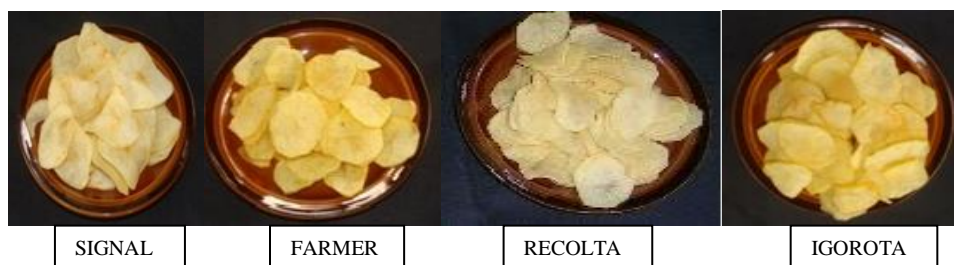
b. Wet season set-up

Lines/Varieties	April – August 2011		Mean
	Low Elev.	High Elev.	
	Baguio	Buguias	
Signal	6.25	6.25	6.25
Farmer	6.50	6.75	6.63
Recolta	6.75	6.50	6.63
Igorota	6.25	6.75	6.50
CV%	30.00	9.00	15.00
ANOVA	n.s.	n.s.	n.s.

Chip Quality. On account of chipping quality, the chip color, texture, crispiness and flavor of the different varieties are shown in Table 9. Desirable light yellow color with excellent or no browning of chips and fries of tubers were harvested from Signal and Recolta while variety Igorota and Farmer were less desirable yellow color but also free from discoloration with slight browning after frying. Chips and French fries obtained from all test varieties were firm textured, very crispy and very perceptible. Low sugar content results in light color while high sugar content causes dark discoloration or browning of chips and fries. On the other hand, tubers with high dry matter content of 18.22 % are very crispy and very perceptible. Varieties with dry matter content higher than 25 % are not recommended for processing because the resulting chips are too hard, not crispy and perceptible (Beukema, 1989).

Table 9. Quality description of different varieties chips after frying.

Lines/Varieties	Quality			
	Color	Texture	Crispiness	Flavor
Signal	Light yellow	Firm	Very crispy	Very perceptible
Farmer	Yellow	Firm	Very crispy	Very perceptible
Recolta	Light yellow	Firm	Very crispy	Very perceptible
Igorota	Yellow	Firm	Very crispy	Very perceptible

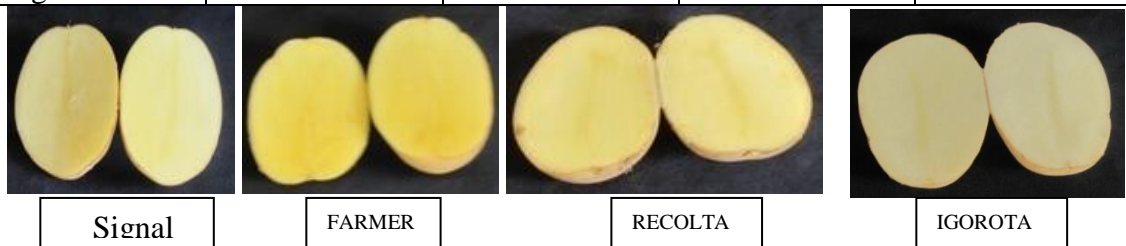


Tuber Characteristics. The characteristics of tubers of the different varieties are presented in Table 10. The shape of tubers of Signal and Farmer were oval to oblong suitable for processing fries while Recolta and Igorota were round to round oval good for processing chips. In terms of skin color, Signal was cream while Farmer, Recolta and Igorota were yellow. Variety

Igorota, Recolta and Farmer had yellow flesh and Signal was whitish in color. All the different varieties are found to have shallow depth of eyes. Tubers with shallow eyes can produce higher yield of fry and chips per unit of fresh weight due to low waste during peeling.

Table10. Tuber Characteristics of Recolta, Farmer, Signal and Igorota

Entries	Tuber Shape	Tuber Color	Flesh Color	Depth of Eyes
Signal	Oval Oblong	Cream	Whitish	Shallow
Farmer	Oval Oblong	Yellow	Yellow	Shallow
Recolta	Round Oval	Yellow	Yellow	Shallow
Igorota	Round Oval	Yellow	Yellow	Shallow



Morphological characteristics. The morphological characteristics of the different potato varieties evaluated are shown in Table 11. The different varieties originated from different countries. Varieties Signal, Recolta, and Farmer came from Holland and check variety Igorota, a locally bred variety came from the Philippines. In terms of maturity period, the two test varieties Recolta and Farmer were short maturing with 80- 90 days, variety Signal and check variety Igorota was late maturing with 90- 100 days after planting.

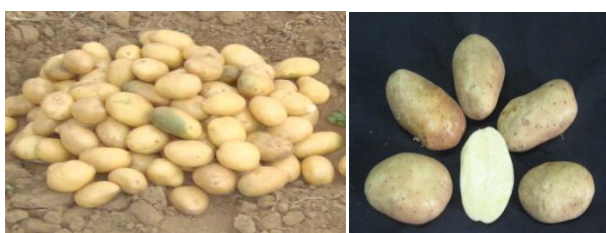
Two types of mode of growth were exhibited by the varieties. Variety Signal, Farmer and check variety Igorota were spreading while variety Recolta was upright to slightly spreading.

Based on stem color, most of the varieties were green, green to purplish and pinkish pigmented. Leaf color texture were characterized as green smooth, green rough, light smooth and dark green smooth.

On shape of tubers, Recolta and Igorota had round to oval, variety Signal and Farmer were oval oblong or elongated. As to the skin and flesh color, all the varieties were all yellow skin with pale yellow, to yellow flesh, only Signal was cream in skin with whitish in flesh color. All the varieties had shallow depth of eyes.

Table 11. Morphological characteristics of the different potato varieties.

Variety	Origin	Potential Yield (t/ha)	Maturity (days)	Reaction to Pest & Diseases	Mode of Growth	Tuber characteristics & DMC	Remarks
Signal	Holland	23	90-100	Resistant to late blight, leaf miner and aphids	Spreading greensprouts, dark green leaves, light smooth to green rough, color and texture of leaves	Oval-oblong, cream skin, whitish flesh, shallow eyes, 19.0-22.0 DMC	New variety, good for processing French fries
Recolta	Holland	18	80 -90	Moderately susceptible to late blight, leaf miner and aphids	Upright, slightly spreading, pinkish sprouts, green leaves & stems, green smooth to light smooth color and texture of leaves	Round-oval yellow skin, yellow flesh, shallow eyes, 22.0-23.0 DMC	New variety, good for processing chips
Farmer	Holland	12	80 -90	Susceptible to late blight, leaf miner and aphids	Upright, slightly spreading, purple sprouts, stem green with purplish pigments, green leaves, green rough to light smooth color and texture of leaves	Oval – oblong, yellow skin, yellow flesh, shallow eyes, 22.0-23.0 DMC	New variety, good for processing French fries
Igorota	Philippines	24	90-100	Resistant to late blight, leaf miner and aphids	Spreading, tall green to pinkish sprouts, stem green and leaves, dark, green light smooth to rough leaf green color and texture	Round to oval yellow skin, yellow flesh, shallow eyes, 22.0-23.0 DMC	Locally-bred variety, new potato variety, processing variety for chips



SIGNAL



RECOLTA



FARMER



IGOROTA

Return on Cash Expense. Table 12 shows the yield in tons per hectare, cost of production, gross income, net income and return on cash expense of the different varieties with positive net profits at varying levels. With the computed total cost of production per hectare of P204, 350.00 in one cropping season, variety Signal generated the highest net profit of P197,450.00 with a return on cash expense of 96.62 %, followed by the check variety Igorota with a gain of P 171,850.00 or a return on cash expense of 84.10 %. Variety Recolta realized an intermediate net profit of P132, 450.00 with a return on cash expense of 64.82 % while Farmer posted the least gain of P148, 250.00 or a return on cash expense of only 23%.

Table 12. Cost and return analysis per hectare of the different potato varieties

A. Labor	Man day (250/day)	Amount
1.Land preparation	20	5,000.00
2.Plot preparation	60	15,000.00
3.Fertilizer application	38	9,500.00
4. Preparation of seed pieces, planting, covering	40	10,000.00
5.Irrigation	45	11,250.00
6.Spraying	35	8,750.00
7.Weeding ,hilling-up and side-dressing	40	10,000.00
8.Harvesting	35	8,750.00
Sub-total	313	78,250.00

B. Input Cost	Quantity	Unit Cost	Total Cost
1.Seed materials	2,500 kgs.	20.00/kg.	50,000.00
2.Inorganic fertilizer	20 bags	1,150.00/bag	23,000.00
3.Organic fertilizer	80 bags	195.00/bag	15,600.00
4.Insecticides	20 li.	1000.00/li	20,000.00
5.Fungicides	20 kgs.	700.00/kg.	14,000.00
6.Sacks	500pcs.	5.00/sack	3,500.00
Subtotal			126,504.00
Grand total			204,350.00

Line/ Varieties	Production Cost Php	BY (tons/ha)	Yield (tons/ha)	BP (PhP/kg)	Gross Income	Net Income	ROCE (%)
Signal	204,350.00	10.22	20.09	10.20	401,800	197,450	96.62
Farmer		10.22	13.63	16.20	252,600	48,250	23.61
Recolta		10.22	16.84	12.15	336,800	132,450	64.82
Igorota		10.22	18.81	10.85	876,200	171,850	84.10

Average farm gate price Php. 20.00/ kg

Break-even Yield (BY) = Total cost/Output price

Break-even Price (BP) = Total cost/Expected yield

SUMMARY AND CONCLUSION

Based on the result of this evaluation, all the selected promising varieties were found suited and adapted in different elevations of Benguet and Mt. Province. Plants from variety Signal, Recolta and Igorota were found moderate to highly vigorous, significantly lesser late blight incidence with lower leafminer and aphid infestations in all growing seasons and elevations. Marketable, total and computed tuber yields were higher in Signal, Recolta and Igorota differing significantly over Farmer. High tuber dry matter content was attained from all varieties which are suitable for processing chips and fries. Signal, Recolta and Igorota were considerably low in sugar content. Chips obtained from Signal and Recolta were light yellow color and free from discoloration while Farmer and Igorota were yellow with slight browning color. All the test varieties have firm texture, very crispy and very perceptible in flavor and taste after frying.

In terms of monetary return, variety Signal generated the highest net income and return on cash expense (ROCE) closely followed by Igorota. Variety Recolta was intermediate while Farmer posted the lowest net profit with the lowest return on cash expense.

RECOMMENDATION

As a result of the series of evaluation, variety Signal and Recolta are highly recommended for table and processing potato in all growing season and elevations of Benguet and Mt. Province. These varieties are recommended to the National Seed Industry Council (NSIC) for commercial production and official release as recommended varieties.

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