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Performance of Orange-fleshed Sweetpotato Varieties in Three Agroecological Conditions in the Cordillera Administrative Region, Philippines

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Abstract

Increasing local production and market availability of fresh and processed orange-fleshed sweetpotatoes (OFSP) could be one nutrition-specific intervention to help promote health and well-being. OFSP is an alternative source of carbohydrates, minerals, and vitamin A. This study used a participatory variety selection approach to evaluate the performance of OFSP varieties for off-season production in three selected areas of CAR under low elevation, mid-elevation, and highland farmers' production systems. Findings show that despite some environmental and production limitations, the different OFSP varieties produced considerable yield and exhibited high dry matter content. The dark orange-fleshed 'Taiwan' variety grown at temperatures ranging from 16-25°C with an elevation of 1,316 masl had the lowest yield and dry matter content with moist textural characteristics. NSIC SP 30 produced low yield and dry matter with considerable acceptable eating qualities. Across locations, var. *Inmitlog*, an early maturing variety with intermediate orange-fleshed color, consistently produced the highest yield and dry matter content with well-accepted eating qualities. This variety showed adaptability to off-season planting conditions at varied production elevations, thus, has potential for contributing to nutrition and food security and as an income-generating crop for marginal farmers.

KEYWORDS

mealiness
on-farm evaluation
elevation
harvesting methods
ß-carotene

Introduction

The Philippine Food Diversification Program promotes the consumption of rice alternatives and wheat flour substitution with composite flours. These efforts are in response to the increasing importation of wheat and rice. The volume of wheat imported had increased from 5,828MT in 2017 to 7,141MT in 2018. For rice, the volume imported in 2017 was 888MT and tremendously increased to 2,006MT in 2018 (Philippine Statistics Authority [PSA], 2019). To help save dollar reserves, the government promotes the production and consumption of rootcrops such as sweetpotato. Sweetpotato, a rich source of carbohydrates, vitamins, and minerals, requires minimal farm inputs, is drought tolerant, and can grow under limited

soil fertility (Philippine Council for Agriculture, Aquatic and Natural Resources Research and Development [PCAARRD], 2006).

Like other root crops except for yacon, sweetpotato is classified as low glycemic food because it contains a considerable amount of dietary fiber (Trinidad et al., 2010). As defined, glycemic index (GI) refers to how fast the blood sugar rises after food ingestion. The slow release of glucose in the bloodstream could help maintain the optimum level of blood glucose. Hence, the consumption of sweetpotato can potentially be a food remedy to diabetic patients or those who need low carbohydrate diets.

In addition to its role in maintaining blood sugar, sweetpotatoes particularly the OFSP, contain significant amount of ß-carotene. ß-carotene is a precursor of vitamin A and has the highest vitamin A activity of all carotenoids (Burri, 2011). Accordingly, one retinol from animal sources is equivalent to 3.33 units of vitamin A activity, while one retinol from ß-carotene is equivalent to 10 units of vitamin A activity. Besides being a vitamin-precursor, ß-carotene also functions as an anti-oxidant as a free radical scavenger (Tilman et al., 2010). Thus, OFSP, which is packed with ß-carotene and energy, can help address the nutritional problem where more than 65% are energy deficient and more than 70% of the population have insufficient Vitamin A intake (Food and Nutrition Research Institute [FNRI], 2008). As recommended, the easiest way to increase vitamin A intake in the diet is by consuming carotene-rich sweetpotatoes (Neela & Fanta, 2019).

However, expanding OFSP cultivation is hampered by the limited availability of OFSP varieties. It has been observed that the commonly planted sweetpotatoes in the Cordillera Administrative Region (CAR) are the white- and yellow-fleshed varieties. Although these varieties contain considerable amounts of carbohydrates and minerals, their ß-carotene ranges only from five to 280 ug/100g (FNRI, 1997). Hence, extensive cultivation of OFSP is encouraged because the most important factor that can help address vitamin A deficiency is the variety used in the intervention (Burri, 2011). But, farmers' variety adoption may depend on its adaptability to local farming system, yield, potential market demand and ability to provide considerable income (Gemechu, 2019; Kurabachew, 2015).

This study aimed to evaluate the suitability of OFSP varieties for off-season production in three selected areas of CAR under low elevation, mid-elevation and highland farmers' production systems. Off-season harvest enables farmers to market their produce at a higher price and provide a continuous supply of sweetpotatoes.

Materials and Methods

Mass Propagation of OFSP Varieties in Farmers' Nursery

Tissue-cultured OFSP, namely *Inmitlog, Taiwan* and *NSIC SP 30* produced at the Northern Philippine Root Crops Research Center of Benguet State University, La Trinidad, Benguet, Philippines, were used in the study. These tissue-cultured plants were mass propagated inside the greenhouse, where tip portions of sweetpotato vines were cut, rooted, and established in sterilized rooting media. These established plant materials were used as source of cuttings for the on-farm evaluation trials in Tinglayan, Kalinga; Pidigan, Abra; and Aguinaldo, Ifugao.

Description of the Experimental Sites

The Municipality of Pidigan, Abra, which lies 59.8 masl, represented low elevation production conditions. The location has tropical climate with two distinct dry and wet seasons. Dry season starts from November to April and the rest of the months are rainy season. The temperature ranges from 20-33°C with 5.77-275.4mm rainfall, 69-84% humidity. The sweetpotatoes were planted after rice on sandy loam soil.

The mid-elevation production conditions was set up in Tinglayan, Kalinga with an elevation of 1,179 masl. The temperature, relative humidity, rainfall range from 14-26°C, 84-91%, and 23.08-392.98mm, respectively. The sweetpotatoes were grown in a rolling terrain, which consists of black mountain soil. No fertilizer was applied by the farmers because the area was previously planted with peanuts.

The high-elevation on-farm trial site was done in the municipality of Aguinaldo, Ifugao, which has an elevation of 1,316 masl. The temperature ranges from 13-25°C and has a humid environment ranging from 85-91%

relative humidity. The area planted was a terraced land consisting of clay loam soil previously planted with legumes. No inorganic fertilizer was applied. The farmer usually utilizes composted hog manure as fertilizer.

On-Farm Selection of Orange-fleshed Sweetpotatoes

Three OFSP varieties *Taiwan, Inmitlog,* and *SP 30* (Figure 1) were planted in a 12-meter plot with 40 hills per plot with 30cm between hills. The experiments were laid out following the randomized complete block design with four replications. The farmers' practices cover land preparation, fertilizer application, irrigation and harvesting practices. Temperature during the growing period was recorded. In Kalinga and Ifugao, no fertilizer was applied because, according to farmers, the sweetpotato will utilize any residual fertilizer left from the previous legume (beans and peanut) planted. In Pidigan, Abra, the farmer broadcasted a very minimal amount of ammonium fertilizer (0.0280g/m^2) 30 days after planting.

For the one-time harvest, roots harvested per replicate were weighed. For farmers who practice the priming method of harvest, the yields were recorded per priming period. The total weight of harvested roots from the 1st to the 4th priming per plot were summed up then converted into tons/ha.

Other important features of the sweetpotatoes were gathered through informal discussions with the farmers. Information taken included the number of days from planting to harvest and other observations on the characteristics of the different OFSP varieties.

Dry Matter Analysis

In addition to yield, the dry matter and eating qualities were considered in variety selection. In a study conducted by Laurie and Magoro, in 2008 and Dibi et al. in 2017, farmers' participatory selection of OFSP varieties was also based on yield, color, dry matter content, and taste.

In Pidigan, Abra site, where commercial growers harvest sweetpotatoes at one time, ten samples were taken per replicate for dry matter evaluation. For the other farmers (Kalinga and Ifugao) who practice the priming method of harvest, samples were taken per harvest.

The average dry matter content from the 1st to 4th priming was computed. Collected samples were chopped, weighed and dried in an oven until samples attained a constant weight.

Figure 1

The Qualities of the Different OFSP Varieties Showing the Leaf and Root Characteristics

Sensory Evaluation

The consumption attributes reflected in the sensory qualities determine the degree of acceptance of consumers (Muresan et al., 2012). The consumption attributes were focused on mealiness and general acceptability. Mealiness is one important factor in determining quality of sweetpotatoes (Kitahara et al., 2017) because such attribute is mostly preferred by consumers (Kathabwalika, 2013). Harvested root samples were boiled and evaluated for mealiness and general acceptability involving 20 panelists per site. Mealiness was assessed using a scale of 1-not mealy; 2-slightly mealy; 3-moderately mealy; 4-mealy. The general acceptability of the different sweetpotato varieties were evaluated using the hedonic rating scale 1=like very much to 7=dislike very much. The acceptability of the overall eating qualities is important in determining the potentials of OFSP as a food-based approach in increasing vitamin A in the diet (Burri, 2011).

Data analysis

Collected data were subjected to statistical analysis. Analysis of variance and comparison of means were estimated separately with statistical package MSTAT-C. The significance of the difference between means was determined using the Duncan's Multiple Range Test (DMRT) at 95% confidence levels (P≤0.05).

Results

Yield Performance of the OFSP varieties

Pidigan, Abra, Philippines

OFSPs were harvested 85 days after planting. The ambient temperature during the growing period ranged from 17°C-34°C. Significant differences between varieties were observed in yield and dry matter content (Table 1 & 2). Of the three OFSP varieties, *Inmitlog* produced the highest yield of 18.4t/ha, which is significantly different from varieties *NSIC SP 30* (16.6 t/ha) and *Taiwan* (13.1t/ha). The dry matter content of *Inmitlog* (29.8 %) and *NSIC SP 30* (27.1%) is significantly different from the *Taiwan* variety (22.5%).

Variety *Inmitlog* had the highest mean sensory

Table 1

The Yield, Dry Matter Content, Mealiness and Sensory Acceptability of Sweetpotatoes Grown in Pidigan, Abra, Philippines, February – May 2016

Variety	Yield, t/ha	Dry Matter Content (%)	Mealiness	General Acceptability
NSIC SP 30	13.6^{b}	27.1^{ab}	2.6^{b}	6.3
Taiwan	13.1^{b}	22.5^{c}	2.3^{b}	6.4
Inmitlog	18.40^{a}	29.8^{ab}	3.1^{a}	6.9

Means with the same letter in a column are not significantly different at P≤0.05 by DMRT.

Table 2

The Yield, Dry Matter Content, Mealiness and Sensory Acceptability of Sweetpotatoes Grown in Tinglayan, Kalinga, Philippines, February – July 2016

Variety	Yield, t/ha	Dry Matter Content (%)	Mealiness	General Acceptability
NSIC SP 30	18.4^{b}	28.2^{b}	2.6	6.2
Taiwan	17.2^{b}	23.3^{c}	2.4	6.5
Inmitlog	21.8^{ab}	32.7^{a}	2.8	6.7

Means with the same letter in a column are not significantly different at P≤0.05 by DMRT.

scores for mealiness (3.1), which is significantly different from the *NSIC SP 30* (2.6) and *Taiwan* (2.3) variety. These differences observed in mealiness did not significantly affect the rating for general acceptability. However, variety *Inmitlog* had the most acceptable general acceptability rating (6.9). The other two OFSP varieties have lower rating scores for general acceptability.

Tinglayan, Kalinga, Philippines

The temperature during the growing period ranged from 15-32°C. The first priming began on variety *Inmitlog* 90 days after planting while priming on the other two varieties started 100-106 days after planting.

The different OFSP varieties vary significantly on yield and dry matter content. Variety *Inmitlog* had the highest yield and dry matter content with 21.8t/ha and 32.7%, respectively. *NSIC SP 30* and *Taiwan* varieties produced considerable yield at 18.4 and 17.2t/ha, respectively. The lowest dry matter content (23.3 %) was recorded from Taiwan variety. Although not significantly different, variety *Inmitlog* was given the highest rating scores for mealiness (2.8) and general acceptability (6.7).

Aguinaldo, Ifugao

The temperature ranged from 16-25°C. Harvesting through priming started 100 days after planting for the variety *Inmitlog* and 110 days after planting for the other two varieties.

The different OFSP varieties showed varied responses under Aguinaldo, Ifugao production conditions (Table 3). Similar to the other sites, var. *Inmitlog* produced the highest yield (26t/ha), dry matter content (30.6%), rating scores for mealiness (3.2), and general acceptability (6.7) which is significantly different from the other two varieties. *Taiwan* variety gave the lowest yield, dry matter content, mealiness, and general acceptability rating of 22.20t/ha, 21.3%, 1.9, and 5.6 respectively.

Discussion

Harvesting using the priming method had higher total yield and dry matter content as compared with one-time harvest. Priming is a method used by subsistence farmers. This method is done by picking only the bigger roots (>100g) and allowing the smaller roots to increase its size. One-time harvest, which commercial growers employ, pick all sizes including the non-marketable sizes at 85-100 days after planting depending on the market price and incidence of sweetpotato weevil infestation. Priming allows roots to develop into its bigger size and accumulate more dry matter content.

Although the duration of the growing period in Pidigan, Abra was shorter, the yield of the sweetpotatoes were considerably higher (13-18t/ha) than the national average yield of 5.56t/ha (PSA, 2013). The good yields gathered from all the sites indicate that the OFSP's tested have inherent characteristics capable of adapting to varied environmental conditions, production constraints, and minimal farm inputs in a short growing period (Trancoso-Reyes et al., 2016). Of the varieties evaluated, the *Inmitlog* variety had the highest yield (18t/ha), indicating that the yield was not affected by the limited soil moisture and hot temperature (25-35°C) experienced by the crop in April and May. The average temperature in February to March ranged from

Table 3

The Yield, Dry Matter Content, Mealiness and Sensory Acceptability of Sweetpotatoes Grown in Aguinaldo, Ifugao, Philippines, February – July 2016

Variety	Yield, t/ha	Dry Matter Content (%)	Mealiness	General Acceptability
NSIC SP 30	22.62 ^{ab}	24.3^{b}	2.1^{b}	6.2^{b}
Taiwan	22.20 ^{b}	21.3^{bc}	1.9^{b}	5.6^{b}
Inmitlog	26.00 ^{a}	30.6^{a}	3.2^{a}	6.7^{a}

Means with the same letter in a column are not significantly different at P≤0.05 by DMRT.

17-23°C. Water available for the plants depended on the residual moisture in the soil, and abundant dew droplets observed early in the morning. Farmers observed the earlier formation of storage roots by *Inmitlog* than the other varieties. Although the marketable root sizes were smaller (50–70g) than the root sizes (>90g) of sweetpotatoes grown during the regular planting season, the number of roots per hill (5 -7) was not affected. Another important feature of *Inmitlog* variety observed by farmers is the spreading vine characteristic which could have helped attain considerable yield despite the limited water available in the soil. According to Placide (2013), this branching feature is a coping mechanism of the plant to explore any moisture available in the soil.

Dry matter content is one important criterion used in the variety selection of sweetpotatoes because it influences the mealy textural characteristics mostly preferred by consumers (Kathabwalika et al., 2013). Mealiness as an attribute for sweetpotato is related to the dry matter content and starch content where the starch granules of mealy cassava and potato varieties are larger than the non-mealy varieties (Safo-Kantanka et al., 1992; Fajardo et al., 2013). Of the three sites, the dark orange-fleshed var. *Taiwan* grown in (Aguinaldo, Ifugao) had the lowest dry matter content (21.3%). It was evaluated as moist, which resulted in lower general acceptability rating. However, in the warmer sites, this variety had higher ratings for mealiness and general acceptability because of its sweet taste and soft textural qualities. No ß-carotene analysis was done under highland conditions, but under lowland conditions, the ß-carotene content of this variety was 7,407ug/100g sample. This result could be similar to the findings of Ginting et al., 2017 that mostly orange fleshed sweetpotatoes with high ß-carotene have low dry matter and high moisture content resulting in moist textural quality after steaming. Specifically, OFSP with dry matter content ranging from 18 – 25% with high ß-carotene has a sweet taste and moist texture after cooking (Troung et al., 2018). These findings require further study on the influence of altitude, climate, and production practices on ß-carotene and dry matter. It could be possible that the decreased dry matter could have resulted in further increase in ß-carotene content at the expense of dry matter accumulation. As reported by Manrique and Hermann (2000), some OFSP clones are more efficient in accumulating ß-carotene when grown under high elevation.

The ideal planting period for sweetpotatoes is when rain starts to fall (May) and immediately after the rainy season (PCAARRD, 2006). This study where OFSP's were planted in February could be considered as an off-season growing period where the crop could have experienced environmental constraints. Despite these conditions, the different OFSP's provided acceptable yield, dry matter content, and consumption attributes (except *Taiwan* var. in Ifugao) 85-100 days after planting. The capacity of sweetpotatoes to accumulate high dry matter is significant in attaining storage root yield (Mohammed et al., 2010). The *Inmitlog* variety which had the highest dry matter content (29.8%-32.7%) in all sites, satisfies the dry matter content (30% and above) required for processing (PCAARRD, 2006). It has potential to be adopted by farmers because it is a well-performing variety in terms of yield, dry matter content, early maturity, and eating qualities (Ngailo et al., 2016; Ssmakula et al., 2014). Well accepted eating quality attributes indicate the potentials of a certain OFSP variety as a food-based intervention in preventing vitamin A deficiency.

Conclusions

The study was conducted in lowland, mid, and high elevation conditions. Results showed that off-season planting of orange-fleshed sweetpotatoes produced high yield and exhibited high dry matter content with acceptable consumption attributes. In all the sites, var. *Inmitlog* produced the highest yield and dry matter content with well-accepted eating qualities. Thus, this variety can be a nutrition or food security crop due to its high ß-carotene content and adaptability to varied environments and minimal farm inputs.

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