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High-Yielding and Acceptable Tugui (*Dioscorea esculenta*) Accessions for the Ilocos

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Abstract

Yam or tugui (*Dioscorea esculenta*) is a cash crop grown by Ilocos farmers in sloping and marginal areas. However, productivity is limited to about 2.6 t ha^{-1}–3.3 t ha^{-1} only due to the absence of a recommended high-yielding variety.

To respond to this need, several experiments were conducted to identify promising accessions that could be recommended to farmers. After three years of evaluation both on-station and on-farm, six accessions (# 9, 3, 2, 1, 4, and 15) were found promising, with mean yields ranging from 13.33 t ha^{-1} to 14.54 t ha^{-1}, which is equivalent to an ROI of at least 1.63. These accessions are also highly acceptable to consumers.

With the promising accessions, planting of tugui can now become a more productive farming endeavor. With these, the marginal and/or idle lands can be made productive and be used to support the government's program on food security.

Keywords: *Dioscorea esculenta, yam accessions, marginal areas*

Introduction

Yam (*Dioscorea*) has been planted by rural folks since time immemorial and has been used not only as food supplement but even as staple food during times of scarcity. Among the more than 50 species of yam, only two species play an important role as source of food: *D. alata* (ubi) and *D. esculenta* (tugui). These crops thrive well in marginal areas with minimal cultural management employed.

The diversity of global genetic resources provides the basis for varietal improvement. Lebot, *et al* (2005) noted that for yam, the possibility of identifying varieties with easy-to-harvest, compact tubers and commercial potentials exists. Mealiness, color, and taste were found to be important for boiled yam, while consistency, color and stickiness determined the general preference for pounded yam. Selection could overcome the difficulty of producing new varieties in a crop where flowering is sporadic and hand pollination is complex.

Several factors explain the poor results from varietal improvement such as the genetic complexity of the *Dioscorea* species complex (polyploid, dioecious plants, whose flowering occurs at different periods according to sex). The poor knowledge of genetic material (which is still insufficiently characterized), and insufficient selection effort, even with promising renewed interest, have been evident in recent years (Akoroda (1998), cited in Vernier and Dansi (2008).

Farmers play a vital role in developing new crop varieties. The Community Biodiversity Development and Conservation Program (CBDCP, 2001) reported that

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farmers use their knowledge and appreciation of local genetic resources to evaluate new materials. Farmers' decisions on whether to replant the introduced materials are based on how these materials match with their local criteria for a promising variety. As such, this study was conducted to select high-yielding and acceptable tugui accessions that could be recommended to farmers.

Methodology

From 2006-2009, field experiments had been conducted to select promising accessions in order to increase the productivity of tugui. Management practices employed in the field experiments were based on the Standardized Techniques for Rootcrops Evaluation developed by the Rootcrops Varietal Improvement Group of the National Seed Industry Council.

Ten accessions of tugui were evaluated; nine of which were collected from local farmers in the Ilocos Region, while the other (PSB VT3) was obtained from the Leyte State University, then Visayas State College of Agriculture, which served as the check variety. The local accessions are generally small (30g->100g) and hairy, while PSB VT3 has big tubers (400g), less hair, and irregular shape.

The experiments were established following the Randomized Complete Block Design with three replications. The experimental unit was a $10m^2$ plot, with two rows each. The rows were spaced 1m apart and each hill was set at 0.5m in between. Fertilizer was basally applied at a rate of 30-30-30 kg N, P_2O_5, K_2O ha^{-1}. Hilling-up was done two months after planting (MAP) and stakes were provided for each hill, which served as anchor for the vines. Weeding was done whenever necessary. No pest control measure was employed, because there was no incidence observed. The plants were harvested at 10 MAP by digging the tubers using a spading fork. Data on yield and its components were taken at harvest time.

Moreover, an organoleptic evaluation determined the acceptability of the different accessions to consumers where a total of 18 tasters participated. The entries were evaluated in terms of appearance, color, aroma, texture, taste, and general acceptability. Since there are no trained tasters in the university, researchers were requested as panelists.

Among the data gathered are the following:

Percent emergence. This was taken at 2 MAP by counting the number of plants that emerged. Percent emergence was computed as:

Percent hills harvested. This was taken at harvest by counting the actual number of hills harvested and was computed as:

$$\text{Emergence (\%)} = \frac{\text{Number of setts emerged}}{\text{Number of setts planted}} \times 100$$

Average number of tubers per hill. The total number of tubers harvested was counted divided by the number of hills harvested per plot.

$$\text{Hills harvested (\%)} = \frac{\text{Actual number of hills harvested}}{\text{Number of setts planted}} \times 100$$

Average tuber size (g). Harvested tubers were counted and weighed. The average tuber size was computed as:

$$\text{Average tuber size(g)} = \frac{\text{Total weight of harvested tubers, kg}}{\text{Total number of harvested tubers}} \times 1000$$

Average yield per hill (g). This was computed as:

$$\text{Ave. yield per hill (g)} = \frac{\text{Total plot yield (kg)}}{\text{Number of hills harvested}} \times 1000$$

Computed yield (t ha^{-1}). This was computed using the formula:

$$\text{Computed yield (t ha}^{-1}\text{)} = \frac{\text{Plot yield (kg) x 10000 m}^2\text{/plot area (m}^2\text{)}}{1000}$$

Percent marketable tubers (based on number and weight). This was determined by counting and weighing all harvested tubers afterwhich all marketable tubers (at least 100g) were counted and weighed.

Percent marketable tuber was computed as:

$$\text{Marketable tuber (by number, \%)} = \frac{\text{No. of mark. tubers}}{\text{Total no. of harvested tubers}} \times 1000$$

$$\text{Marketable tuber (by weight, \%)} = \frac{\text{Wt. of mark. tubers}}{\text{Total wt. of harvested tubers}} \times 1000$$

Results and Discussion

Yield Evaluation of the Tugui Accessions

Ten accessions of tugui were evaluated within three cropping seasons (CY 2006 -2009). Result of the series of experiment shows significant differences among entries wherein PSB VT3 consistently produced the highest yield. However, statistical analysis showed that most of the local accessions were found comparable to PSB VT3, particularly during the first two years of evaluation. In the third year, a general decline in yield of all the entries was observed due to the low crop survival caused by heavy typhoons and sustained rain.

Mean yield after three years of evaluation showed that PSB VT3 produced the highest yield of 19.80t ha^{-1}. However, except for Accessions #6 and 14, the local accessions were found comparable, with a mean yield of 13.33 t ha^{-1} to 15.61 t ha^{-1}. Highest yielders among the local accessions were #7 (15.61 t ha^{-1}), #9 (14.54 t ha^{-1}), #3 (14.48t ha^{-1}), #2 (14.19t ha^{-1}), #1 (14.11t ha^{-1}), #4 (13.60t ha^{-1}), and #15 (13.33t ha^{-1}). It must be noted that all the entries produced a much higher yield compared to the national, regional, and provincial average yield of 4.41t ha^{-1}, 3.24t ha^{-1} and 3.30t ha^{-1}, respectively.

Table 1. Computed yield (t ha^{-1}) of 10 tugui accessions evaluated for yield and acceptability, CY 2006-2009, MMSU, Batac, Ilocos Norte.

ACCESSION NO.	COMPUTED YIELD (t ha^{-1})			MEAN ACROSS YEARS
	CY 2006-2007	CY 2007-2008	CY 2008-2009	
	*	**	**	*
1	13.61^{ab}	21.45^{a}	7.27^{bc}	14.11^{ab}
2	15.46 ^{ab}	19.28 ^{ab}	7.84^{bc}	14.19^{ab}
3	13.13 ^{ab}	23.65 ^{a}	6.68^{bc}	14.48^{ab}
4	16.88 ^{ab}	19.83 ^{ab}	4.08^{c}	13.60^{ab}
6	11.70 ^{abc}	13.50 ^{bc}	7.97^{bc}	11.05^{b}
7	19.27 ^{a}	17.06 ^{ab}	10.51^{b}	15.61^{ab}
9	17.25 ^{ab}	19.65 ^{ab}	6.47^{bc}	14.54^{ab}
14	6.67 ^{bc}	18.81 ^{ab}	8.92^{b}	11.47^{b}
15	13.36 ^{ab}	17.76 ^{ab}	8.86^{b}	13.33^{ab}
18 (PSBVT3)	21.98 ^{a}	22.95 ^{a}	14.48^{a}	19.80^{a}

* - significant at 5% level
** - significant at 1% level
Means followed by the same letter are not significantly different at 1% level by DMRT.

Data on yield components were taken during and after harvest (Tables 2-6). Percent hills harvested during the first year of trial ranged from 55% - 91.70%, where Accession #14 significantly produced the lowest while the rest of the entries were comparably higher. In the second and third trials, there was no significant difference among the entries. It is noted, however, that percent hills harvested in the last year of trial was relatively low, averaging only from 50% to 80%. As mentioned earlier, this was due to the occurrence of heavy typhoons and sustained rain during the season, which affected not only the survival of the crop but its general performance as well.

The local accessions significantly produced more tubers as compared with PSB VT3, except in CY 2008-2009 wherein all entries were found comparable (Table 3). Generally, the local accessions produced more than 10 tubers per hill, with Accession # 3 producing the most (19.66) in CY 2007-2008. Despite the lower number of tubers produced, PSB VT3 had bigger tubers as evidenced by the significantly higher mean tuber weight, which was consistent during the evaluation period (Table 4). Among the local accessions, #7, 9, 4, and 15 produced bigger tubers than the others.

In the first year of trial, significant differences were observed among entries in terms of marketable yield based on number of tubers. PSB VT3 had the highest percentage (65.20%) but was comparable with Accession #4 (52.39%). However, no significant differences were observed in the second and third year of evaluation. The same result was observed in terms of percent marketable tubers based on weight. In addition to Accession #4, Accessions #7 and #9 were observed to have comparable yield with PSB VT3 during the first year of evaluation.

Table 2. Percent hill harvested of 10 tugui accessions evaluated for yield and acceptability. CY 2006-2009. MMSU, Batac, Ilocos Norte.

ACCESSION NO.	HILLS HARVESTED (%)		
	CY 2006-2007	CY 2007-2008	CY 2008-2009
	*	ns	ns
1	83.30[ab]	86.70	65.00
2	83.30 [ab]	85.00	73.30
3	86.70 [ab]	86.70	61.70
4	83.30 [ab]	81.70	50.00
6	73.30 [ab]	68.30	73.30
7	88.30 [ab]	71.70	76.70
9	81.70 [ab]	76.70	58.30
14	5.00 [b]	76.70	71.70
15	81.70 [ab]	86.70	66.70
18 (PSBVT3)	91.70 [a]	83.30	80.00

* - significant at 5% level
ns – not significant
Means followed by the same letter are not significantly different at 1% level by DMRT.

Table 3. Average number of tubers per hill of the 10 tugui accessions evaluated for yield and acceptability, CY 2006-2009, MMSU, Batac, Ilocos Norte.

ACCESSION NO.	AVE. NO. OF TUBER PER HILL		
	CY 2006-2007	CY 2007-2008	CY 2008-2009
	**	**	ns
1	14.20[a]	17.66[ab]	10.55
2	14.87 [a]	16.93 [ab]	11.00
3	12.87 [ab]	19.66 [a]	10.28
4	14.47 [a]	14.60 [bcd]	6.74
6	12.73 [ab]	17.06 [ab]	9.41
7	16.00 [a]	16.00 [bc]	10.13
9	13.47 [ab]	17.66 [ab]	11.06
14	9.07 [bc]	16.40 [abc]	10.02
15	11.73 [ab]	13.13 [cd]	11.30
18 (PSBVT3)	6.40 [c]	9.73 [e]	8.77

** - significant at 1% level
ns – not significant
Means followed by the same letter are not significantly different at 1% level by DMRT.

Table 4. Average tuber weight (g) of the 10 tugui accessions evaluated for yield and acceptability. CY 2006-2009. MMSU, Batac, Ilocos Norte.

ACCESSION NO.	AVERAGE TUBER WEIGHT (g)		
	CY 2006-2007	CY 2007-2008	CY 2008-2009
	**	**	*
1	58.49[c]	72.14[cde]	53.71[b]
2	67.37 [bc]	73.37 [cde]	48.68[b]
3	62.95 [bc]	75.17 [b-e]	49.92[b]
4	81.98 [bc]	78.08 [b-e]	55.39[b]
6	67.09 [bc]	73.60 [cde]	56.78[b]
7	77.16 [bc]	84.97 [bcd]	68.76[ab]
9	93.09 [b]	96.17 [b]	52.68[b]
14	53.00 [c]	71.56 [cde]	62.50[b]
15	63.04 [bc]	86.18 [bc]	55.09[b]
18 (PSBVT3)	157.66 [a]	138.01 [a]	83.24[a]

* - significant at 5% level
** - significant at 1% level
Means followed by the same letter are not significantly different at 1% level by DMRT.

Table 5. Percent marketable tuber (by number) of 10 tugui accessions evaluated for yield and acceptability, CY 2006-2009, MMSU, Batac, Ilocos Norte

ACCESSION NO.	MARKETABLE TUBER (%)		
	CY 2006-2007	CY 2007-2008	CY 2008-2009
	*	ns	ns
1	32.20[bc]	40.29	39.97
2	37.97 [bc]	41.01	48.79
3	39.17 [bc]	45.38	46.06
4	52.39 [ab]	49.39	43.62
6	29.96 [c]	39.63	39.68
7	40.73 [bc]	41.01	50.30
9	40.97 [bc]	48.71	53.64
14	27.78 [c]	22.77	42.84
15	33.42 [bc]	33.56	46.97
18 (PSBVT$_3$)	65.20 [a]	27.35	58.53

sgnificant at 5% level
ns – not significant
Means followed by the same letter are not significantly different at 1% level by DMRT.

Acceptability Evaluation of the Tugui Accessions

To test the acceptability of the different accessions among consumers, an organoleptic evaluation was conducted involving 18 tasters. Medium-sized tubers were boiled and the test entries were evaluated in terms of appearance, color, aroma, taste, texture, and general acceptability (Table 6.

Organoleptic evaluation in terms of acceptability ranged from moderately acceptable to very acceptable. It was observed, however, that the local accessions were far more acceptable than PSB VT3. Local accession #3 was most acceptable followed by #1, 14, and 15. The least acceptable was #7.

Table 6. Percent marketable tuber (by weight) of the 10 tugui accessions evaluated for yield and acceptability. CY 2006-2009. MMSU, Batac, Ilocos Norte.

ACCESSION NO.	MARKETABLE TUBER (%)		
	CY 2006-2007	CY 2007-2008	CY 2008-2009
	*	ns	ns
1	57.99^{bc}	65.04	65.40
2	63.47^{bc}	68.42	76.74
3	63.66^{bc}	66.92	73.08
4	77.93^{ab}	81.43	63.07
6	52.19^{c}	69.67	66.22
7	72.93^{abc}	73.49	75.47
9	70.66^{abc}	80.08	78.50
14	59.49^{bc}	69.93	68.17
15	59.78^{bc}	75.88	69.86
18 ($PSBVT_3$)	87.12^{a}	71.37	82.28

* - significant at 5% level
ns – not significant
Means followed by the same letter are not significantly different at 1% level by DMRT.

Cost and Return Analysis

A simple economic analysis of planting tugui is shown in Table 8. Tugui, a low input crop, only requires fertilizer (30-30-30 kg N, P_2O_5, K_2O/ha) as material input aside from the setts, which was valued at P2.00 per piece. Of the P62,786.00 total production cost, material input accounted for P45,136.00 (71.88%). Labor cost, which included land preparation, fertilizer application, planting, hilling-up, staking, harvesting and sorting accounted for only P17,650.00.

With a projected price of ₱15.00 kg^{-1} harvest, break-even yield was computed at 4.185 t ha^{-1}. This means that any excess from the break-even yield would be the farmers' income. In this experiment, all of the entries produced yields higher than the break-even yield, implying an income for the farmer.

Profitability of each accession, however, was dependent on the individual yields produced. As basis of computation, the lowest average yield of 11.05t ha^{-1} (Acc. #6) was used. Net income was computed at P102,964, which was equivalent to an ROI of 1.63.

Conclusions and Recommendations

The adoption of the promising accessions is expected to increase productivity. These accessions readily fit in farmers' field because these were obtained from local farmers and were evaluated on farm. In addition, these accessions passed the organoleptic evaluation and were acceptable to consumers; hence, farmers are assured of marketing their products.

Table 7. Acceptability of boiled tubers of 10 tugui accessions evaluated for yield and acceptability. MMSU, Batac, Ilocos Norte

ENTRY	APPEARANCE	COLOR	AROMA	TASTE	TEXTURE	GEN. ACCEPTABILITY
1	2.63	2.00	2.38	2.57	2.42	2.23
2	2.90	2.53	3.00	3.35	3.31	3.22
3	2.15	1.80	2.10	2.50	2.10	1.84
4	2.85	2.71	2.30	2.65	2.89	3.33
6	3.33	2.61	3.33	3.05	3.27	3.53
7	3.95	2.85	3.20	3.60	4.21	4.39
9	3.70	2.80	2.80	3.15	3.68	3.47
14	2.60	2.40	2.30	2.60	2.25	2.35
15	3.20	3.00	2.65	2.50	2.82	2.60
PSB VT_3	5.16	4.92	3.88	4.27	3.75	5.05

Rating Guide: 1- very acceptable to 9- not acceptable

Table 8. Cost and return analysis[1] of planting tugui.

ITEM	COST (₱)
I. Cost of Production	
A. Material inputs	
1. Fertilizer, 4.28 bags @ ₱1200.00/bag[2]	5, 136.00
2. Sett, 20,000 pc @ ₱2/pc	40,000.00
	45,136.00
B. Labor	
1. Land preparation, ₱0.40/m^2	4,000.00
2. Fertilizer application, 3 MD[3]	525.00
3. Planting, 10 MD	1,750.00
4. Hilling-up, 15 MD	2,625.00
5. Staking (including gathering of stakes), 20 MD	3,500.00
6. Harvesting, 25 MD	4,375.00
7. Sorting, 5 MD	875.00
	17,650.00
Total Cost of Production	62,786.00
II. Returns	
A. Break-even yield	4.185 t
B. Gross income[4]	165,750.00
C. Net income	102,964.00
D. ROI	1.63

[1] *The lowest average yield, 11.07 t ha^{-1} (Acc. # 6), was used as basis in the computation*
[2] *Recommended Rate is 30-30-30 kg N, P_2O_5, K_2O/ha*
[3] *P175.00/MD*
[4] *P15.00/kg*

Despite the fact that the crop matures in 10 months, additional income is guaranteed once this crop is planted in areas, which usually lay barren, with an ROI of 1.63. Although the computed net income is relatively low considering that it matures in at least 10 months, it should be noted that this crop thrives well in marginal areas. Hence, planting tugui in those areas would make these lands productive and offer an opportunity to farmers, especially in the uplands, to either increase or to have additional income.

Anchored on the findings, re-introduction of the outstanding accessions in major tugui growing areas should be done in order for farmers to benefit from the technology. Likewise, further testing should be conducted in more sites in order to satisfy the National Seed Industry Council requirements for variety registration.

MMSU Tugui 1
Yield (t ha^{-1}): 14.48
No. of Tuber/Hill: 14.27
Tuber Wt.(g): 62.68
Acceptability: very acceptable

MMSU Tugui 4
Yield (t ha^{-1}): 14.54
No. of Tuber/Hill: 14.06
Tuber Wt.(g): 80.64
Acceptability: acceptable

MMSU Tugui 5
Yield (t ha^{-1}): 14.11
No. of Tuber/Hill: 14.13
Tuber Wt.(g): 61.44
Acceptability: acceptable

MMSU Tugui 6
Yield (t ha^{-1}): 14.19
No. of Tuber/Hill: 14.26
Tuber Wt.(g): 63.14
Acceptability: acceptable

MMSU Tugui 7
Yield (t ha^{-1}): 13.60
No. of Tuber/Hill: 11.93
Tuber Wt.(g): 71.81
Acceptability: acceptable

MMSU Tugui 8
Yield (t ha^{-1}): 13.33
No. of Tuber/Hill: 12.05
Tuber Wt.(g): 68.10
Acceptability: acceptable

Fig. 1. The promising tugui *(Dioscorea esculenta)* accessions.

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