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CORRELATION OF AGRONOMIC CHARACTERS IN POTATO ACCESSIONS GROWN ORGANICALLY

ABSTRACT

Twenty potato accessions grown organically were characterized morphologically. Correlation analysis was done to determine the relationship among agronomic characters and to identify characters associated with marketable yield and harvest index.

Number of secondary stems, haulm weight, canopy cover at 75 DAP, diameter of stem and length of roots had significant positive correlation with marketable yield. Likewise, dry matter content of tubers and leaf area showed significant positive correlation with harvest index. Characters sig-nificantly correlated with marketable yield and harvest index could be used as selection indices for potato accessions grown under organic produc-tion.

INTRODUCTION

In the Philippines, 74 % of the total potato production area comes from Benguet and Mountain Province, while the remaining 26 % were from Southern and Northern parts of Mindanao (PCARRD, 1997).

According to researchers, potato farmers in Benguet and Mountain Province use tremendous amount of synthetic fertilizers and pesticides to increase their production. These conventional practices, however, may lead to soil acidity and the decrease in population of natural enemies. Another major effect is pollution of the soil, water and air which may cause health hazards to people in the community. Considering these problems, alterna-tive production practices should be practiced. One of the practices which is

gaining popularity is organic farming.

According to Petzoldt (2005) organic production is a method of pro-duction that uses practices or materials which are biologically enhancing to the soil and plants. The principle of organic farming is to replenish and maintain long term soil fertility by providing the optimal conditions for biological activity. In addition, encouraging the use of local resources, re-cycled nutrient and maintaining biodiversity will minimize the occurrence of pests.

In an organic farm therefore, varieties should be resistant to pests. Thus, selection of varieties suitable for organic production is important. In the selection of varieties, morphological characters are significant. At pres-ent, there are no available information in Benguet and Mountain Province to show correlation of morphological characters with yield in an organic farm.

Before correlation could be done, characterization should be ac-complished. Standardized descriptors are used to characterize germplasm. Breeders could use descriptors as references for exploiting new traits that are desirable and related to yield of the crop. Characters and traits should be identified to be correlated with yield and later, improvement could be done (Borromeo, et al., 1994).

This study was conducted to determine the agronomic characters significantly correlated with marketable yield and harvest index in potato accessions grown organically.

The study was conducted at the Benguet State University Experi-mental Station, Balili, La Trinidad, Benguet from May to August 2005.

MATERIALS AND METHODS

Background of the experimental area

The experimental area was not applied with synthetic fertilizers and pesticides for three consecutive years. In the first year of cultivation, the area was planted with corn and fallowed. It was planted with legumes in

the second year and was fallowed in the third year.

Land preparation and lay-out of the experiment

An area of 300 m2 was thoroughly prepared and further divided into three blocks. Each block was subdivided into 20 plots measuring 1 m x 5 m

representing the twenty treatments. The experiment was laid-out following the randomized complete block design (RCBD).

Preparation of planting materials and planting

Rooted stem cuttings of the twenty potato accessions were acquired from the Northern Philippines Root Crop Research and Training Center (NPRCRTC). The cuttings were planted at a distance of 25 cm x 30 cm between hills and rows.

Cultural management practices

The treatments were equally applied with compost at a rate of 10 kg/5 m2. Cultural practices such as irrigation and weeding were uniformly employed in all the treatments. There was no spraying of pesticides; instead yellow traps were used for leaf miner control. The area was surrounded with corn and marigold to encourage diversity and reduce pest population.

Characterization

Characterization was done based on agro-morphological characters using the descriptors lists for potato by the International Potato Center (CIP, 2000).

Data gathered

Only those characters with significant correlation with marketable yield and harvest index are described as follows:

1. **Canopy cover.** Canopy cover was gathered at 30, 45, 65, 75 DAP with the use of a wooden frame of 120 cm x 60 cm having equally sized 12

cm x 6 cm grids. Holding the grids over the foliage of four previously marked plants, grids covered with effective leaves were counted.

2. **Diameter of the stem (mm).** The diameter of the mid-portion of the main stem was measured using a vernier caliper.

3. **Number of secondary stems.** Secondary stems of the sample plants were counted.

4. **Haulm weight (g).** Ten sample plants were weighed at harvest.

5. **Leaf area (cm^2).** Leaf area was taken by tracing the leaves of the sample plants on a graphing paper. The squares covered were count-ed and divided by four.

6. **Tuber yield parameters.** Yield was gathered from ten sample plants per plot at 90 DAP.

    a. **Weight of marketable tubers (g).** Marketable yield was recorded by weighing the tubers that are of marketable size, not malformed, free from damages caused by pests.

    b. **Weight of non-marketable tubers (g).** Non-marketable yield was gathered by weighing the tubers that are of marble size, malformed and damaged by pests.

7. **Dry matter content (DMC) of tubers (%).** Dry matter content was computed by using the following formula:

$$DMC\ (\%) = 100 - \%\ MC$$

Where: MC = Moisture content

$$\%\ MC = \frac{\text{Fresh weight- Oven dry weight}}{\text{Fresh weight}} \times 100$$

8. **Harvest Index (HI).** This was computed by getting the ratio of the economic to biological yield as follows:

$$\% \text{ HI} = \frac{\text{TDMC}}{\text{LDMC+SDMC+RDMC+TDMC}} \times 100$$

Where: TDMC = Tuber DMC
LDMC = Leaf DMC
SDMC = Stem DMC
RDMC = Root DMC

Analysis of Data

Data were statistically analyzed using the analysis of variance (ANOVA) for randomized complete block design (RCBD). Significance of difference between treatments means were tested using the Duncan's Mul-tiple Range Test (DMRT) at five percent level of probability.

Correlation analysis was done. Correlation coefficient is a statistical measure which is used to find out the degree and direction of relationship between two or more variables. It helps in determining the yield contribut-ing characters in plant breeding (Singh, and Narayanan, 1993).

According to Downie and Health (1983), the degree of relationship between two variables can be measured using the Pearson Product Moment (ρxy) coefficient which characterizes the interdependence of X and Y. The coefficient ρxy is a parameter which can be estimated from sample data us-ing the formula:

$$r = \frac{\sum xy - \frac{(\sum x)(\sum y)}{n}}{\sqrt{\left(\sum x^2 - \frac{(\sum x)^2}{n}\right)\left(\sum y^2 - \frac{(\sum y)^2}{n}\right)}}$$

RESULTS AND DISCUSSION

Agronomic characters with significant correlation with marketable yield and harvest index are discussed.

Canopy Cover

The canopy covers of the potato accessions are shown in Table 1. Significant differences were observed among the accessions. At 30 DAP, accession 384558.10 had the highest canopy cover which is comparable with 387039.15 while accessions 376004 and FS1 had the lowest canopy covers.

At 45 DAP, accessions 384558.10 and 380251.17 had the highest canopy covers. At 65 DAP, accession 380251.17 had the highest canopy cover which was not significantly different with 387039.15 but is comparable with accession 384558.10. At 75 DAP, accession 384558.10 had the highest canopy cover.

The results showed that accessions 384558.10 and 380251.17 consistently showed high canopy covers in all dates. Canopy cover obtained at the later stages of growth may not be reliable since plants were infected with late blight.

Leaf Area

Significant differences were observed among the accessions for leaf area. Accession 285411.22 significantly had the largest leaves followed by accession 676070.

The smallest leaves were obtained from accessions Igorota and 676103. Differences in leaf area could be due to variability in leaf shapes and dissection (Table 2).

Diameter of Stem

Variability was observed among the potato accessions for stem diameter. Accession IP84007.67 was noted to have the widest stem which

Table 1. Canopy cover of twenty potato accessions at 30, 45, 65 and 75 DAP

ACCESSION	CANOPY COVER* (DAP)			
	30	**45**	**65**	**75**
384558.10	43.00$_{a}$	56.00$_{a}$	51.00$_{ab}$	51.00$_{abc}$
380251.17	29.00$_{cd}$	50.33$_{a}$	55.33$_{a}$	58.00$_{a}$
IP84007.67	22.00$_{bcd}$	27.33$_{bcd}$	49.00$_{abc}$	50.67$_{abc}$
285411.22	24.00$_{bcd}$	36.00$_{abc}$	43.50$_{abc}$	52.00$_{ab}$
676070	26.00$_{bcd}$	38.67$_{abc}$	44.50$_{abc}$	33.50$_{bcd}$
387443.22	24.67$_{bcd}$	41.67$_{abc}$	46.00$_{abc}$	35.67$_{bcd}$
387039.15	35.33$_{ab}$	40.33$_{abc}$	54.67$_{a}$	51.33$_{ab}$
676008	19.00$_{cd}$	28.00$_{bcd}$	38.67$_{abcd}$	34.00$_{bcd}$
387410.7	18.67$_{cd}$	27.00$_{bcd}$	20.00$_{ef}$	15.00$_{fg}$
575003	19.00$_{cd}$	18.33$_{de}$	27.00$_{bcd}$	12.00$_{g}$
15.97.8	16.67$_{d}$	16.33$_{e}$	26.00$_{cde}$	24.00$_{def}$
720045	17.67$_{d}$	17.67$_{de}$	16.00$_{f}$	15.00$_{fg}$
676004	16.00$_{d}$	20.00$_{cde}$	23.67$_{def}$	28.67$_{cde}$
720071	22.00$_{bcd}$	27.00$_{bcd}$	30.00$_{bcd}$	31.67$_{bcd}$
285378.27	34.00$_{abc}$	42.33$_{ab}$	44.33$_{abc}$	44.33$_{abc}$
720097	16.33$_{d}$	15.00$_{e}$	17.00$_{f}$	18.00$_{efg}$
676103	18.00$_{d}$	21.00$_{bcd}$	18.00$_{f}$	16.67$_{fg}$
FS1	16.00$_{d}$	24.50$_{bcd}$	23.00$_{def}$	26.67$_{def}$
Igorota	20.67$_{bcd}$	24.67$_{bcd}$	16.67$_{f}$	15.33$_{fg}$
Ganza	27.00$_{bcd}$	27.67$_{bcd}$	31.67$_{abcd}$	40.00$_{abc}$
CV (%)	**32.24**	**35.23**	**35.39**	**35.03**

**Means with the same letter are not significantly different by DMRT (P > 0.05).*

was comparable with Ganza. According to Smith (1968) as cited by Gayadon (1999), larger stems were found to have greater assimilation rate per unit plant and leads to higher yield. On the other hand, accession 676103 was observed to have the narrowest stem (Table 2).

Table 2. Diameter of stem and length of main stem of the twenty potato ac-cessions

ACCESSION	LEAF AREA* (cm^2)	DIAMETER OF STEM* (mm)	LENGTH OF MAIN STEM* (cm)
384558.10	56.67_{ef}	5.30_{bcd}	26.13_{ef}
380251.17	59.27_{def}	5.67_{abc}	52.70_{b}
IP84007.67	86.83_{bc}	6.83_{a}	40.80_{bcd}
285411.22	134.58_{a}	5.37_{bcd}	41.33_{bcd}
676070	95.40_{b}	4.43_{cde}	37.47_{bcd}
387443.22	49.50_{ef}	5.40_{bcd}	41.80_{bcd}
387039.15	59.13_{def}	5.60_{abc}	50.03_{b}
676008	52.63_{ef}	5.37_{bcd}	33.40_{cde}
387410.7	51.63_{ef}	3.83_{fg}	32.83_{def}
575003	52.28_{ef}	3.77_{fg}	31.30_{def}
15.97.8	29.23_{gh}	3.90_{ef}	25.30_{fg}
720045	30.57_{gh}	3.67_{fg}	26.60_{ef}
676004	46.53_{f}	4.53_{cde}	37.00_{bcd}
720071	43.50_{fg}	4.90_{bcd}	78.33_{a}
285378.27	48.63_{ef}	5.03_{bcd}	47.83_{bcd}
720097	64.07_{de}	5.60_{abc}	49.83_{bc}
676103	20.67_{h}	3.40_{g}	90.00_{a}
FS1	54.23_{ef}	4.97_{bcd}	23.70_{g}
Igorota	25.70_{h}	4.13_{de}	38.90_{bcd}
Ganza	74.33_{cd}	6.30_{ab}	42.37_{bcd}
CV (%)	**15.64**	**15.30**	**20.43**

**Means with the same letter are not significantly different at by DMRT (P > 0.05).*

Haulm Weight

As shown in Table 3, accession 380251.17 had the heaviest haulm weight of 80.32 g which was comparable with accession 387039.15 while Igorota had the lightest haulm weight with a mean of 6.84 g. Highly significant differences in the haulm weight existed among the twenty potato accessions.

Table 3. Haulm weight of twenty potato accessions

ACCESSION	HAULM WEIGHT* (g/plant)
384558.10	5.03$_{f}$
380251.17	80.32$_{a}$
IP84007.67	53.00$_{abc}$
285411.22	51.44$_{abc}$
676070	21.02$_{bcd}$
387443.22	14.94$_{bcd}$
387039.15	55.07$_{ab}$
676008	40.37$_{abcd}$
387410.7	12.86$_{cdef}$
575003	26.06$_{bcd}$
15.97.8	7.07$_{ef}$
720045	18.67$_{bcd}$
676004	37.54$_{bcd}$
720071	48.33$_{abc}$
285378.27	45.10$_{abc}$
720097	35.28$_{bcd}$
676103	15.44$_{bcd}$
FS1	10.13$_{def}$
Igorota	6.84$_{ef}$
Ganza	26.29$_{bcd}$
CV (%)	**68.01**

**Means with the same letter are not significantly different at by DMRT (P > 0.05).*

Tuber Yield

Parameters Weight of Marketable Tubers

Accession 387039.15 produced the heaviest marketable tubers, followed by accession 384558.10. Accession 676103, on the other hand, which produced the least number of marketable tubers, also produced the lowest weight of marketable tubers (Table 4).

Table 4. Marketable, non-marketable and total yield of twenty potato accessions

ACCESSION	WEIGHT OF MARKETABLE TUBERS* (g/plant)	WEIGHT OF NON-MARKETABLE TUBERS* (g/plant)	TOTAL YIELD* (g/plant)
384558.10	89.75$_{b}$	10.14$_{c}$	99.89$_{ab}$
380251.17	78.51$_{b}$	9.81$_{c}$	88.46$_{ab}$
IP84007.67	79.67$_{b}$	28.83$_{a}$	108.5$_{ab}$
285411.22	18.71$_{cd}$	7.63$_{c}$	26.34$_{b}$
676070	2.50$_{d}$	3.76$_{d}$	58.62$_{ab}$
387443.22	29.59$_{cd}$	13.81$_{b}$	40.48$_{b}$
387039.15	145.98$_{a}$	9.65$_{c}$	155.64$_{a}$
676008	11.69$_{cd}$	3.87$_{d}$	15.56$_{b}$
387410.7	30.49$_{cd}$	6.04$_{c}$	36.53$_{b}$
575003	22.99$_{cd}$	5.72$_{c}$	139.52$_{a}$
15.97.8	23.36$_{cd}$	6.19$_{c}$	29.55$_{b}$
720045	53.33$_{bcd}$	13.33$_{b}$	66.67$_{ab}$
676004	29.30$_{cd}$	3.78$_{d}$	33.07$_{b}$
720071	10.32$_{cd}$	4.16$_{d}$	14.41$_{b}$
285378.27	26.93$_{cd}$	4.23$_{d}$	31.16$_{b}$
720097	29.96$_{cd}$	3.83$_{d}$	33.79$_{b}$
676103	7.14$_{d}$	3.65$_{d}$	10.79$_{b}$
FS1	22.81$_{cd}$	10.36$_{c}$	33.16$_{b}$
Igorota	14.20$_{cd}$	10.13$_{c}$	24.33$_{b}$
Ganza	57.54$_{bc}$	9.25$_{c}$	66.79$_{ab}$
CV (%)	**56.98**	**68.64**	**88.86**

**Means with the same letter are not significantly different by DMRT (P > 0.05).*

Weight of Non-marketable Tubers

Accession IP84007.67 significantly had the highest weight of non-marketable tubers produced followed by accession 387443.22. On the other hand, accession 676103 which had the least number of non-marketable tu-bers also had the lowest weight of non-marketable tubers produced (Table 4).

Total Weight of Tubers

Significant differences in the total weight of marketable tubers were noted among the accessions. Accession 387039.15 produced the heaviest weight of tubers and was comparable with accessions 384558.10, 380251.17, IP84007.67, 676070, 720045 and Ganza while accession 676103 produced the lightest weight of tubers (Table 4).

Table 5. Dry matter content of tubers and harvest index of twenty potato accessions

ACCESSION	DRY MATTER CONTENT OF TUBERS*	HARVEST INDEX*
384558.10	28.88$_{a}$	0.32$_{abc}$
380251.17	28.90$_{a}$	0.36$_{a}$
IP84007.67	26.53$_{abc}$	0.27$_{bcd}$
285411.22	21.77$_{abc}$	0.26$_{cde}$
676070	22.17$_{abc}$	0.23$_{def}$
387443.22	29.17$_{a}$	0.27$_{bcd}$
387039.15	19.83$_{bcd}$	0.24$_{def}$
676008	22.87$_{abc}$	0.22$_{ef}$
387410.7	21.20$_{abc}$	0.32$_{abc}$
575003	20.53$_{bcd}$	0.22$_{ef}$
15.97.8	18.23$_{cd}$	0.21$_{f}$
720045	18.50$_{cd}$	0.21$_{f}$
676004	27.93$_{ab}$	0.30$_{abc}$
720071	22.37$_{abc}$	0.29$_{abc}$
285378.27	23.50$_{abc}$	0.33$_{abc}$
720097	16.17$_{d}$	0.21$_{f}$
676103	6.77$_{e}$	0.11$_{g}$
FS1	27.57$_{ab}$	0.34$_{ab}$
Igorota	22.50$_{abc}$	0.27$_{bcd}$
Ganza	23.30$_{abc}$	0.31$_{abc}$
CV (%)	**18.82**	**14.42**

**Means with the same letter are not significantly different by DMRT (P > 0.05).*

Dry Matter Content of Tubers

Highly significant differences were noted among the potato accessions for DMC. Accession 387443.22 had the highest DMC of tubers and not significantly different with accessions 384558.10 and 380251.17 but is comparable with accessions 676004 and FS1. Accession 676103, on the other hand, had the lowest DMC of tubers (Table 5).

Harvest Index

Highly significant differences on the harvest index existed among the twenty accessions of potato as shown in Table 5. Accession 380251.17 had the highest harvest index and is comparable to FS1. Accession 676103 which had the lowest DMC of tubers produced the lowest harvest index. The high harvest indices obtained for most of the accessions indicate high dry matter partitioning. This further shows that accessions 380251.17, 3845458.10, FS1 and Ganza are efficient in partitioning carbohydrates to the tubers.

Correlation Between Marketable Yield and Harvest Index and Other Agronomic Characters

Correlation coefficients between marketable yield and other characters are shown in Table 6. A strong significant positive correlation was identified between marketable yield and number of secondary stems and haulm weight. This implies that marketable yield increases as the number of secondary stems increases. This result however contradicts with the findings of Sawicka, et.al. (2007) where the number of stems is negatively correlated to yield of potato. The positive significant correlation between marketable yield and haulm weight implies that as haulm weight increases, marketable yield increases. Significant positive correlation existed between market-able yield and canopy cover at 75 DAP, diameter of stem, as well as the length of roots. This confirms the study of Shagol (2001) on sweetpotato, that canopy cover, number of leaves, stem diameter, number of nodes, as well as vine length have positive correlation with marketable yield.

Harvest index showed significant positive correlation with dry mat-ter content of tubers and leaf area. This implies that as DMC of tubers and

leaf area increases, harvest index increases. The strong positive correlation of DMC of tubers with harvest index indicates high dry matter partitioning in the tubers. This result confirms the result of Gibson (2002) under conventional potato production which shows that DMC of tubers was posi-tively correlated with harvest index.

Table 6. Correlation coefficient of marketable yield and harvest index with other characters (r = 0.329)

CHARACTERS	CORRELATION COEFFICIENT	
	MARKETABLE YIELD	HARVEST INDEX
Plant height at 30 DAP	0.115	-0.078
Plant height at 90 DAP	0.211	-0.241
Canopy cover at 30 DAP	0.005	0.107
Canopy cover at 45 DAP	0.241	-0.001
Canopy cover at 65 DAP	0.224	0.066
Canopy cover at 75 DAP	0.418*	-0.102
Number of leaves	0.249	-0.014
Leaf area	0.093	0.371*
Length of main stem	-0.165	-0.187
Diameter of stem	0.354*	0.048
Length of internodes	0.143	0.006
Number of nodes	0.187	-0.135
Number of secondary stem	0.444**	-0.198
Number of roots	0.027	-0.049
Length of roots	0.328	-0.041
Number of eyes/tuber	0.178	0.840**
DMC of tubers	-0.205	0.069
Haulm weight	0.444**	1.00
Harvest index	-0.083	
Marketable yield	1.00	

** - Significant at 5 % level of probability ** - Highly significant at 5 % level of probability*

CONCLUSION AND RECOMMENDATION

Variability existed among the different accessions in the morphological characters measured. Marketable yield was significantly correlated with number of secondary stems, haulm weight, canopy cover at 75 DAP, diameter of stem and length of roots. Significant positive correlation exists between harvest index and dry matter content of tubers and leaf area.

Canopy cover at 75 DAP, number of secondary stems and haulm weight could be used as indices for selection of varieties or accessions for organic production of potato. Since morphological characters are difficult to assess and sometimes not reliable, a more precise way to characterize is the use of DNA markers. Research towards DNA profiling could be done for the best potato accessions for organic production.

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