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Yield stability and acceptability of two new *Solanum* potato varieties in Uganda

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Abstract

Stability analysis is a popular statistical procedure in testing and selection of new crop varieties. In this procedure, emphasis is often put on stable and high yield often with less regard to users' perspectives. The success of any breeding agenda is how much its products are adapted, adopted and utilised. High yields are sometimes obtained at the cost of acceptable user attributes often resulting in limited variety adoption. Consequently, in addition to routine yield stability analysis, two candidate potato varieties, CIP 387121.4 and CIP 381471.18, other advanced clones from population A and B and older potato varieties in Uganda were subjected to user acceptability during agronomic evaluation for the candidate varieties before official release. Yield stability analysis in the highlands over four seasons showed that CIP 381471.18 was quite stable with a non-significant ($P < 0.05$) gradient (*b*) close to unity ($R^2 = 0.972$). On the other hand CIP 387121.4 was less stable ($b = 1.3$, $R^2 = 0.88$). The two clones contrasted with older cultivars, Victoria and Kisoro with slopes at 0.19 (R^2=0.014) and 0.085 (R^2=0.88), respectively. In multi-site testing, the *b*-value for CIP 381471.18 was 0.94 (R^2=0.997) and 1.66 (R^2=0.95) for CIP 387121.4. Farmer acceptability assessment using qualitative variables indicated that CIP 381471.18 had a higher acceptability index (84.6%) than Victoria (55.6%) and NAKPOT1 (69.8%) however; both were lower than Uganda 11 (91.9%). When the test clones were assessed for palatability and consumer acceptability, CIP 381471.18 had an index of 78.8% while CIP 387121.4 had 72.2%. This contrasted with values for Victoria (64.4%) and Uganda 11 (52.5%). Such information can been used to support candidate variety agronomic and yield stability as an additional basis for superiority of candidate varieties. This approach is likely to enhance adoption and utilisation of new crop varieties and profitably thus transforming the breeders' effort into farmers' cash income.

Keywords: Potato qualitative variables, stability analysis user-acceptability index

Introduction

Stability and adaptation analyses are important tools in cultivar selection and adaptability tests (Hill *et. al.,* 1998). Because of high genotype and environment interactions, variety selection becomes a daunting task for breeders in search of crop varieties that are adaptable to diverse environments (Hill *et. al.,* 1998, Assefa *et. al.*, 1995, Tullu *et. al.*, 1994). When high yielding, disease resistant cultivars with wide adaptation are being sough; there is sometimes a tendency to lose certain of attributes that users cherish in older varieties. In variety testing therefore, consumer acceptability and product quality assessment is important if newly released crop varieties are to be adopted by a wider spectrum of users. This approach is used in potato variety identification in Uganda for potato clones that are presented for inclusion in the national variety list through farmer participatory breeding and user acceptability assessment (Hakiza *et. al.,* 2001). In commercialised agriculture, farmers will adopt a variety that is highly marketable, one that has the most preferred attributes by the consumers even when it suffers from biotic and abiotic stresses (Adipala *et. al*., 2000). This is one of the reasons why farmers tend to keep old varieties in the presence of new, high yielding and stress-tolerant ones. Such attributes in potato include tuber shape, eye-depth, tuber skin colour, tuber flesh colour, after-cooking taste, appearance, and quality of fried products. Although some of these characteristics are regarded by some authors as fancy and could be ignored for a while (Simmonds, 1971), they play a significant role in Uganda for potato consumer acceptability and therefore influence farmer variety adoption among commercial potato producers. Adipala *et. al.,* 2000 stress that in addition to farmers adopting a variety that is primarily high yielding and disease resistant, the authors mention that farmers will quest for a variety that is highly market-demanded. However, the authors did not show why the consumers prefer certain potato varieties although tuber skin colour was mentioned in one instance (Adipala *et al.,* 2000). Mugisa-Mutetika, 1997 noted that in addition to high yields, taste, seed colour, cooking time and market potential influenced bean variety adoption. Therefore, in demand-driven production, farmers will tend to adopt varieties with attributes that the market prefers. Consequently, it is common to find farmers still growing old and disease susceptible varieties but which, are preferred by the market. This means that there are other attributes that appear minor, that are often ignored by breeders, but play a significant role in consumer preference and therefore influence farmer variety adoption in market-oriented enterprises. Therefore, potential varieties need to be evaluated for acceptability among the end-users for external, physical characteristics and culinary qualities in addition to routine stability analysis. Consequently, candidate varieties which are selections from population A potato germplasm known to possess major genes to late blight resistance were evaluated together with advanced clones from population B. Population B germplasm is are potato breeding materials where major genes to LB resistance have been removed and the quantity of minor or horizontal resistance genes increased (Landeo, 2002).

Materials and Methods

Two advanced potato clones, CIP 381471.18 and CIP 387121.4, referred to here as candidate varieties, formally obtained from the International Potato Centre (CIP) and several other potato clones and older varieties were tested in Uganda over seasons and across sites as a requirement for having newly introduced germplasm included in the national variety list. The candidate varieties were evaluated across four contrasting sites in Uganda in 2001 and 2002 with cultivars Kabale (CIP 374080.5), Uganda 11 (CIP 720097), and Victoria (CIP 381381.20) as standard checks and seven other clones from population B potato genotypes that were bred with no major gene resistance to late blight (LB). This germaplsm collection was tested at Kalengyere, 2450 m above sea level (a.s.l.), Kachwekano, 2100 m a.s.l., Buginyanya, 2000 m a.s.l. and Mbarara, 1500 m a.s.l. during 2001 and 2002. At each site, three replications per entry were planted and a randomised complete block design (RCBD) was adopted. The experiment at each site was given standard agronomic practices and only two fungicidal sprays with mancozeb 80 WP at 25 and 50 days after planting as a synergist to resistance against late blight. In another experiment, the test clones were evaluated four consecutive seasons between 1999B and 2001A at Kalengyere, a hotspot for late blight together with older varieties Victoria and Kisoro (381379.9) which, are from the same breeding population (A). In this experiment, an RCBD was used with three replications per season. The crop was sprayed twice with a contact fungicide, mancozeb 80 WP besides other standard potato crop agronomic practices. For both experiments each plot per cultivar was 12.6 M^2 comprising of four rows each 4.5 M long planted with 15 seed tubers. Late blight disease data was collected as infection severity as percent leaf area affected from a whole plot by visual inspection using the CIP scale of 1-9 where 1 corresponds to no visible late blight symptoms and 9 equivalent to 100% foliage damage (Henfling, 1987). Disease data was collected at weekly intervals starting from 30 days after planting as percent leaf area affected later converted to area under disease progress curve (Campbell and Madden, 1990). The experiments were harvested at full crop maturity and crop performance was recorded as yield in $MtHa^{-1}$ from the whole plot per entry. Differences among treatments were tested using analyses of variance while regression procedures were used to test the stability of the genotypes across seasons and sites (Opondo and Ombakho, 1997, Eberhart and Russell, 1966). At the time of harvesting, a group of forty people which including farmers, agricultural extension personnel, NGO representatives and fast-food kiosk owners, were requested to rate the test materials for physical attractiveness of the tubers using an arbitrary scale of 1-5, where score 1 was very poor and score 5 represented a very acceptable skin colour, tuber shape, tuber size distribution, eye depth, qualitative yield and uncooked flesh colour. At the same time, samples were taken and prepared for palatability tastes in several recipes (Hakiza *et. al.* 2001). The potatoes were prepared as French fries, whole boiled or a boiled and mashed recipe. A group of untrained panel comprising of 30 people was requested to rate the different recipes basing on after-cooking flesh colour, taste of whole boiled and, mashed tubers, mealiness and quality of French fries. Each of these attributes was ranked as previously described for external characteristics. An index of acceptability of each clone per attribute expressed as a percentage was calculated using the formula;

$$100 \times (S_1 n_a + S_2 n_b \ldots\ldots S_i n_i)/S_m N$$

where, S_i is a given score, n_i is number of individual giving the score S_i, S_m is the maximum attainable score and N is the total number of individuals in the panel (Scolte, 1994). The mean index of the attributes was used a criterion for clone acceptability by the end-users.

Results and discussion

Performance of candidate varieties and population B potato genotypes at Kalengyere, Kachwekano, Mbarara and Buginyanya in Uganda

Assessment of late blight disease at Kalengyere, Kachwekano, Mbarara and Buginyanya showed that the candidate varieties were comparable to Uganda 11, a LB resistant check, at different sites and did not overall differ significantly (P<0.05) from it (Table 1). The candidate varieties were all superior to Victoria, Kabale, and selections from population B genotypes (Table 1). A combined analysis across locations showed that clone 381471.18 was superior to all the test clones and 387121.4 was next to Uganda 11 in LB resistance (Table 1). When the candidate varieties were compared with advanced clones for yield at each site, data indicated that the candidate varieties yielded significantly (P < 0.05) higher than other entries (Table 2). A combined analysis across sites showed that the candidate varieties occupied the first two top positions and significantly (P < 0.05) differed from all the clones and checks (Table 2). Although one of the most popular varieties, Uganda 11, was comparable to the candidate varieties in LB resistance, it had poor yields (Table 1 and

Table 1: Comparison of late blight (LB) infection severity as area under disease progress curve (AUDPC) of candidate varieties and population B genotypes at Kalengyere, Kachwekano, Mbarara and Buginyanya, Uganda in 2001 and 2002

Entry	LB-Area under disease progress curve				
	Kalengyere	Kachwekano	Mbarara	Buginyanya	Combined
Kabale	913.5^{ABC}	1418.7^{A}	476.9^{ABC}	1864.6^{A}	1168.2^{A}
381471.18	733.3^{C}	372.8^{D}	109.4^{EF}	61.78^{E}	319.3^{F}
Uganda 11	262.5^{D}	859.3^{BC}	188.1^{DEF}	203.5^{E}	378.4^{F}
387121.4	460.3^{D}	638.8^{CD}	288.8^{CDEF}	266.2^{DE}	413.5^{F}
392127.256	745.5^{C}	539.0^{CD}	56.8^{F}	530.8^{CDE}	468.0^{EF}
Victoria	796.3^{ABC}	946.8^{BC}	717.5^{A}	18.2^{E}	619.7^{DE}
392618.256	892.5^{ABC}	1117.5^{AB}	612.5^{AB}	261.5^{DE}	720.7^{CD}
392127.270	771.8^{BC}	1215.3^{AB}	345.6^{BCDE}	810.4^{BCD}	785.6^{BCD}
392170.250	1020.0^{AB}	969.5^{ABC}	341.3^{BCDEF}	1069.7^{BC}	850.1^{BC}
391049.255	883.8^{ABC}	1264.3^{AB}	297.5^{CDEF}	1220.1^{B}	916.2^{B}
392144.250	1033.0^{A}	990.5^{ABC}	450.6^{ABCD}	1339.6^{AB}	953.1^{B}
392618.250	1003.0^{AB}	1276.4^{AB}	345.6^{BCDE}	1229.5^{B}	963.2^{B}
Mean	792. 9	967.0	287.7	739.4	713.0
$Lsd_{0.05}$	249.2	459.0	287.7	600.8	193.8

Table 2: Mean fresh tuber yield ($MtHa^{-1}$) of candidate varieties with standard checks and population B genotypes at Kalengyere, Kachwekano, Mbarara and Buginyanya, Uganda in 2001 and 2002

Entry	Mean fresh tuber yield ($MtHa^{-1}$)				
	Kalengyere	Kachwekano	Mbarara	Buginyanya	Combined
387121.4	43.9^{A}	23.2^{A}	20.4^{AB}	18.2^{AB}	26.4^{A}
381471.18	39.3^{AB}	26.5^{A}	27.4^{A}	12.1^{BCD}	26.3^{A}
392127.270	32.5^{BC}	9.9^{CDE}	13.2^{BCD}	15.2^{ABC}	17.7^{B}
392618.256	20.3^{DE}	16.2^{B}	14.3^{BCD}	17.9^{AB}	17.2^{BC}
Uganda 11	30.5^{BCD}	10.9^{CD}	18.7^{BC}	8.6^{DE}	17.2^{BC}
Victoria	13.9^{E}	12.7^{BC}	14.3^{BCD}	21.1^{A}	15.5^{BCD}
392170.250	21.2^{DE}	11.8^{CD}	12.5^{BCD}	10.0^{CDE}	14.1^{CDE}
392618.250	27.5^{CD}	8.7^{DEF}	9.6^{D}	9.1^{CDE}	13.7^{CDE}
Kabale	27.6^{CD}	5.75^{F}	10.9^{CD}	8.2^{DE}	13.1^{DE}
392127.256	23.9^{CDE}	12.6^{BCD}	10.7^{CD}	4.9^{E}	13.0^{DE}
391049.255	20.9^{DE}	5.7^{F}	9.4^{D}	10.4^{CDE}	11.6^{E}
392144.250	15.1^{E}	6.5^{EF}	11.1^{CD}	12.8^{BCD}	11.4^{E}
Mean	26.4	12.5	14.4	12.5	16.4
$Lsd_{0.05}$	10.9	4.0	8.2	6.6	3.6

Table 3: Stability analysis across four sites, Kalengyere, Kachwekano, Mbarara, and Buginyanya, Uganda for candidate varieties in 2001 and 2002.

Variety	Regression coefficient	Coefficient of determination	Standard error of slope	Mean response
381471.18	0.94	0.997	0.055	31.0
387121.4	1.66	0.948	0.391	29.2
Victoria	0.043	0.154	0.102	13.6
Kabale	1.515	0.989	0.163	14.7
392170.250	0.696	0.997	0.038	15.2
392127.270	1.621	1.0	0.016	18.6

Table 4: Across season (1999A to 2001B) analysis for candidate varieties in the highlands of southwestern Uganda.

Variety	Regression coefficient	Coefficient of determination	Standard error of slope	Mean response
381471.18	1.19	0.835	0.265	31.3
387121.4	1.3	0.638	0.492	25.5
Kisoro	0.85	0.888	0.219	24.5
Victoria	0.19	0.014	0.810	27.5
387146.48	0.92	0.880	0.170	23.6

Table 5: Assessment of tuber characteristics[1] as a test of acceptability of candidate varieties among farmers and consumers in Uganda.

Cultivar	Acceptability index (%)						
	Skin colour	Tuber shape	Tuber size	Eye depth	Yield[1]	Flesh colour	Mean[2] index
381471.18	76.9	83.3	91.7	84.0	94.2	77.6	84.6
384329.21	70.2	63.5	71.2	74.4	63.5	66.0	68.2
387121.4	80.7	74.4	70.5	53.9	73.1	74.4	71.2
387143.37	59.0	56.4	60.9	66.0	62.2	70.5	62.5
387146.48	65.4	69.9	73.3	73.1	76.3	71.2	71.5
NAKPOT1	69.2	71.8	71.2	66.7	68.0	71.8	69.8
Uganda 11	93.0	94.9	98.7	81.4	96.2	87.2	91.9
Victoria	56.1	57.7	46.2	58.3	45.5	69.2	55.6

[1]Qualitative assessment . [2]Acceptance threshold = grand mean index = 71.9% (N=40)

Table 6: Assessment of culinary characteristics for testing acceptability of candidate varieties and potential users.

Cultivar	Variety acceptability indices (%)					
	Flesh colour after cooking	Taste of boiled tubers	Taste of mashed tubers	Mealiness	Chips	Mean* index
381471.18	73.4	68.6	68.8	69.4	81.3	72.2
384329.21	64.1	54.7	51.6	48.4	60.9	55.9
387121.4	75.0	81.3	82.8	75.0	79.7	78.8
387143.37	48.4	39.1	40.6	45.3	51.6	45.0
387146.48	67.2	51.6	50.0	54.7	48.4	54.4
NAKPOT1	67.2	50.0	67.2	64.1	57.8	61.3
Uganda 11	64.1	43.8	37.5	46.9	70.3	52.5
Victoria	71.9	37.5	79.7	64.1	68.8	64.4

*Acceptance threshold = grand mean index = 60.5% (N=30)

2). This is an indication of the superiority of candidate varieties over Uganda 11 one of the popular potato varieties in Uganda.

Stability analysis of candidate varieties

Stability analysis of the candidate varieties across four locations in 2001 and 2002 showed that regression coefficients (*b*) were not significant ($P \leq 0.05$. The *b*-value for CIP 381471.18 was very close to one with a low standard error of the slope and high R^2 (Table 3), indicating that this clone was stable across these sites. The *b*-value for CIP 387121.4 was high (Table 3) indication of sensitivity of this clone to favourable environments (Hill *et al.*, 1998). A little change in environmental conditions would lead to a rapid decline in mean response (Hill *et al.*, 1998, Becker, 1981) of this clone. This clone should therefore be restricted to zones where it is most adapted for example, Mbale (Buginyanya) and Kabale (Kachwekano and Kalengyere), which are highland areas (>2000 m a.s.l.). Clone 381471.18 can be profitably grown in diverse zones from as low as 1500 m a.s.l. among the sites that were used in this study.

Across-season analysis of the candidate varieties at Kalengyere Research Station from 1999A to 2001B showed that the regression coefficients (*b*) for test cultivars were not significant ($P < 0.05$) which showed independence of genotype-response to differences in seasons. However, the coefficients of determination of the candidate varieties were high indicating that the data of these clones best fitted the regression model (Table 4).The gradients for CIP 381471.18 was close to unity (Table 4) indicating a high stability if this clone (Hill *et al.*, 1998) across seasons. The slope for CIP 387121.4 was 1.3 indicating the sensitivity of this clone in less favourable seasons (Hill *et. al.*, 1998).

Acceptability of candidate potato varieties among farmers and consumers

The candidate varieties with several other cultivars were assessed among farmers and other users for their acceptability using physical tuber characteristics and culinary qualities. External characteristic assessment indicated that Uganda 11 was superior to all the test clones but closely followed by 381471.18 (Table 5). Cultivars with mean index above 71.9% were generally appealing to the users basing on their external characteristics. Cultivar 387121.4 scored just below the acceptance threshold (Table 5).

When the candidate varieties were tested for their culinary qualities, the candidate varieties were ranked highly for table qualities (Table 6). The candidate varieties were preferred to Victoria, NAKPOT1 and Uganda 11. For the purpose of processing, the candidate varieties were ranked higher than Uganda 11 (Table 6), the most popular variety in Uganda for French fries. Overall, the candidate varieties were ranked higher than Uganda 11 one of the popular potato varieties in Uganda in the fast foods market. The implication is that the candidate varieties can provide a better alternative to Uganda 11 that is affected by many biotic constraints despite its popularity especially among urban consumers. From this assessment, a clone with mean index greater than 60.5% in the present circumstances was considered acceptable to users (Table 6). Compared with other checks in combination with agronomic attributes, the candidate varieties were in every way superior to cultivars Victoria and Kabale.

Conclusion

The two candidate varieties performed outstandingly since 1999 in diverse environments. Clone CIP 381471.18 had higher stability across seasons and sites indicating that it has attributes for wider adaptability. Clone CIP 387121.4 was sensitive and would perform best in most favourable environments. User assessment indicated that the two clones can substitute some of the current popular varieties whereby some have narrow adaptability, suffer from major stresses while others are deficient in client-desired characteristics. From users' perspective and stability analysis, it highly likely that clone 381471.18 will be quickly and widely adopted than clone 387121.4. This analysis is as important as stability analysis for yield and disease resistance if newly named cultivars are to be widely adopted, utilised and converted in cash income by farmers. This approach of client-driven variety selection is likely to yield higher dividends for both breeders and farmers and could be an integral part in crop variety improvement and adaptation in an effort to enhance adoption.

References

Adipala, E., Namanda, S., Mukalazi, J., Abalo, G. Kimoone, G. and Hakiza, J.J. 2000. Farmer potato variety selection criteria in Uganda. *African Potato Association Conference Proceedings* 5: 439-443.

Assefa, S. Geleta, B. and Tanner, D.G. 1995. Yield stability analysis of nine spring bread wheat genotypes in the central highlands of Ethiopia. *African Crop Science Journal*. Vol. 3 : 35-40.

Becker, H.C. 1981. Correlation among some statistical measures of phenotypic stability. *Euphytica* 30:835-84.

Campbell, C.L. and Madden, L.V. 1990. Introduction to Plant Disease Epidemiology. John Wiley and Sons, New York. 532pp.

Eberhart, S.A and Russell, W.A. 1966. Stability parameters for comparing varieties. *Crop Science* 6:36-40.

Hakiza, J.J., Kanzikwera, C.R. and Kakuhenzire, R.M. 2001. Solanum potato. In Mukiibi, J.K. (Ed.): *Agriculture in Uganda*. Fountain Publishers. Pages 252-278.

Henfling, J.W. 1987. Late Blight of Potato Phytophthora infestans. Technical Information Bulletin 4. CIP, Lima, Peru. 17pp

Hill J., Becker, H.C., and Tigerstedt, P.M.A. 1998. *Quantitative and Ecological Aspects of Plant Breeding*. Chapman and Hall. London. p280.

Landeo, J.A. 2002. Durable résistance, Quantitative or Qualitative. In : Late Blight : Managing the Global Threat. Proceedings of Global Initiative on Late Blight . July 2002, Hamburg Germany. International Potato Centre.

Mugisa-Mutetika, M. 1997. Factors influencing adoption and dissemination of new bean cultivars in Uganda. *African Crop Science Society Proceedings* 3, 1349-1355.

Opondo, R.M. and Ombakho, G.A. 1997. Yield evaluation and stability analysis in newly selected 'KSA' cotton cultivars in western Kenya. *African Crop Science Journal* Vol. 5 : 119-125.

Scolte, 1994. *Methodology in Crop Experimentation.* Department of Agronomy. Wageningen Agricultural University. Wageningen. The Netherlands. 153pp

Simmonds, N.W. 1971. The potential of potatoes in the tropics. *Tropical Agriculture (Trinidad)* 48: 291-299.

Tullu, A, Bejiga, G., Tsegaye, S. and Eshete, M. 1994. Performance and stability of selected chickpea genotypes in central highlands of Ethiopia. *African Crop Science Journal* Vol. 1 : 55-57.