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IDENTIFICATION OF STABLE POTATO VARIETIES FROM EXOTIC SOURCES FOR TABLE AND PROCESSING PURPOSES IN BANGLADESH

B.C. Kundu[1], M.A. Kawochar[1], S. Naznin[1], M. Mostofa[1*], M.M. Ali[1], M.M.H. Tipu[2], M.B. Anwar[3], N.U. Ahmed[4], A.K. Saha[5] and M. Harun-or-Rashid[1]

[1]Tuber Crops Research Centre, Bangladesh Agricultural Research Institute
Gazipur, Bangladesh
[2]Department of Pathology, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh
[3]Regional Agricultural Research Station, Bangladesh Agricultural Research Institute
Jashore, Bangladesh
[4]Tuber Crops Research Sub Centre, Bangladesh Agricultural Research Institute
Munshiganj, Bangladesh
[5]Regional Agricultural Research Station, Bangladesh Agricultural Research Institute
Rangpur, Bangladesh

ABSTRACT

Seven exotic varieties of advanced generation (Cimega, Farida, Jelly, Memphis, Panamera, Taisiya and 7four7) along with four checks (BARI Alu-7, BARI Alu-13, BARI Alu-25 and BARI Alu-28) of potato were evaluated at five agro-ecological locations of Bangladesh during 2016-17 to identify stable varieties for table and processing purposes. Results indicated significant variation among the varieties and locations. To identify the early bulking varieties, tuber yield at 65 DAP was recorded, which showed that the variety 7four7 gave maximum yield (28.1 t ha^{-1}). So, it can be selected as an early market variety. The maturity period of the varieties varied from 85 to 95 days. At the final harvest (95 DAP), the highest average yield over location was also produced by 7four7 (38.7 t ha^{-1}). The varieties Cimega and Memphis also gave comparable yields to that of 7four7 (37.3 and 36.7 t ha^{-1}, respectively). Farida was found suitable for table purposes because of its high yield, medium-sized tubers, oval and smooth shape and good eating qualities. These four varieties were significantly better than the checks in yield. The variety Taisiya produced tubers with good size and shape but low in dry matter content. Memphis produced maximum large-sized tubers, and so it may be suitable for processing. All the varieties produced good dry matter (18-20%). From the AMMI stability analysis, Cimega and 7four7 were the most stable varieties. Taisiya and Memphis were found as medium stable. Based on the stability, tuber yield and other characters, these four

[*] Corresponding Author: marufsau@hotmail.com

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varieties may be selected for further studies in the RYT before release as specific purpose varieties.

Keywords: Exotic varieties, AMMI stability analysis, *Solanum tuberosum*, Tuber yield.

INTRODUCTION

Potato is a very promising food crop in Bangladesh. It produces maximum fresh as well as dry matter per unit area and time compared to any other food crop (Singh, 2008). For the last few years, Bangladesh has been producing more than ten million tons of potatoes per year (BBS, 2017; BBS, 2018). This high production sometimes produces a glut in the market, resulting in a price fall. As a result, farmers and traders face significant losses. So, this problem must be solved to encourage the farmers to grow more potatoes because this crop can be grown in a very short time with less energy, can be harvested and processed very easily, can provide more energy and nutrition than any other crop (Rashid and Hoque, 2009). The most important solutions for this problem are: i) to improve the quality of the produce so that our potatoes are easily accepted by the consumers of other countries, ii) to increase the size and dry matter of our potatoes so that those can be used in the processing industries, and iii) to motivate the mass people to eat more potatoes as a staple food and as a vegetable (Kundu and Kabir, 2012). Whatever may be the purpose, stable varieties with higher yield and good tuber qualities for export, processing and home use are imminent.

Potato is grown in different elevations such as mid altitudes to very high mountain tops and different environments such as humid to dry areas. So, the improvement in productivity will require the development of potato varieties best adapted to a wide range of environments (Tessema et al., 2020). Potato variety development using selection and hybridization is a common practice in most potato growing countries of the world (Kundu et al., 2020). Introduction and selection of exotic varieties have been the most common method of variety identification under Bangladesh conditions within a short period (Rashid et al., 1987; Kundu et al., 2013; Kundu et al., 2020). Usually, four to six generations of selection are needed before the release of a variety to see its rate of degeneration, yield stability, disease susceptibility and post-harvest qualities. The present-day investigations also include the qualitative studies related to export and processing like a bigger size, good shape, high dry matter and low reducing sugar content of the tubers. The objective of this study was to identify stable varieties for table and processing purposes.

MATERIALS AND METHODS

Seven exotic varieties like Cimega, Farida, Jelly, Memphis, Panamera, Taisiya and 7four7, along with four standard varieties viz. BARI Alu-7 (Diamant), BARI Alu-13

(Granola), BARI Alu-25 (Asterix) and BARI Alu-28 (Lady Rosetta) as checks were evaluated at five locations across the country (Munshiganj, Bogra, Jashore, Jamalpur and Debiganj) during 2016-17 in RCB (Randomized Complete Block) design with three replications. These materials were evaluated and selected in PYT (Preliminary Yield Trial) and SYT (Secondary Yield Trial) in the earlier generations (TCRC, 2015; TCRC, 2016). Whole tubers of 30-35 mm size (Debiganj source) were planted in 3 m × 3 m plots following 60 cm × 25 cm spacing. Planting was done on November 20-25, 2016. Fertilizers were applied @ 325-220-250-120 kg/ha of Urea, TSP, MOP and Gypsum, respectively. Necessary intercultural operations were done as per TCRC's recommendation (Mondal et al., 2011). Haulm killing was done at 65 and 95 DAP. Harvesting was done after 10 days of haulm killing. Data were recorded on plant height, number of stems/hill, days to maturity, number of tubers/hill, the weight of tubers/hill, tuber yield/plot, dry matter content of tubers, and tuber grading by number and weight. Plant height, number of stems/hill, number of tubers/hill and the weight of tubers/hill were measured as the mean of randomly selected 10 plants. Data was analyzed statistically and means were separated by using DMRT. Stability analysis was done following AMMI model as described in Zobel et al. (1988).

RESULTS AND DISCUSSION

The average performances of the varieties over the locations are presented in Table 1. Varieties differed significantly for all the traits. Plant height is an important foliage character for potatoes. Too tall plants are not desirable for potatoes. Plants usually fall down after a certain height and create an overlapping of the leaves inducing shading and microclimate, while too short plants minimize the photosynthetic area of the plant resulting in poor yield. So, 50 to 70 cm height is expected. In this study, the average plant height varied from 56.5 to 75.7 cm. The tallest plants were produced by the variety Panamera. The shortest plants (56.5 cm) were found in the variety 7four7 (Table 1).

The number of stems per plant is a desirable character for a potato variety. Maximum number of stems per plant is required for early soil coverage. Higher stem number is desirable for a higher number of tubers per plant, while the minimum number of stems is associated with the lower number of tubers per plant. A lower number induces a bigger size, which is desirable for industrial uses but undesirable for table purposes (NIVAA, 2009). The average number of stems/hill varied from 3.69 (Memphis) to 6.61 (Diamant) (Table 1).

The 65DAP output of a variety is desirable in some cases. Some farmers in the northern districts go for early planting and 60-65 day harvesting for early tuber supply in the market when the sale price of the newly harvested tubers is very high. Due to early harvesting, farmers can go for the second winter crop. The highest

average yield at 65 DAP was given by the variety 7four7 (28.1 t ha^{-1}), closely followed by Farida (26.3 t ha^{-1}), Cimega and Panamera (Table 1). When location yield was considered, the highest yield was found (40.6 t ha^{-1}) in Farida at Debiganj, but the variety 7four7 gave the highest yield in all the locations except at Munshiganj (Table 2). So, 7four7 variety may be selected for commercial cultivation as an early variety. When the location average yield was considered, Bogura gave the highest yield, closely followed by Debiganj; the other three locations gave very low yield. So, it can be assumed that the northern stations are better suited for early market tuber production. Varieties Farida and 7four7 are the two best varieties for early tuber production, especially in the northern region of the country. The maturity period did not vary much (Table 1). On average, all the varieties matured within 95 days. When the individual location was considered, Cimega, Memphis and 7four7 were somewhat late maturing.

The number of tubers per hill and the weight of tubers per hill, respectively indicate the tuber size and yield potentiality of a potato variety. For processing qualities, we need minimum number of tubers per plant but higher yield. On the contrary, we need more medium-sized tubers with high potentiality for table purposes. In that case, the variety Memphis produced larger tubers and high yield (Table 1). So, Memphis variety should be explored for processing purposes. Varieties 7four7, Cimega, Farida and Panamers should be tried further for table potatoes.

Tuber yield at maturity varied from 30.0 to 38.7 t ha^{-1} in imported varieties, while the check varieties produced 24.8 to 27.5 t ha^{-1} (Table 1). All the imported varieties are good considering yield, but for commercial feasibilities, these varieties should be further checked for other qualities like pest resistance, degeneration rate, and preservation and post-harvest losses. When location-wise yield was considered (Table 3), Farida topped the list yielding 57.4 t ha^{-1} at Debiganj, followed by 7four7, Cimega and Memphis at the same station. These varieties also performed better in yield at most of the stations. The mean yields of these varieties were also significantly higher than the checks (Table 3). When the station averages were considered, Debiganj was the best, followed by Munshiganj and Bogura. The performances at Jamalpur were very poor, and that of Jashore was medium. Usually, Jamalpur yields are better than those of the other stations, but this year, all the varieties, including checks, performed very poorly at this station. It might be due to some stress conditions, either from the fertilizer or water or from any other management problem (Handayani et al., 2019).

Table 1. Mean performances of the exotic potato varieties in AYT (average of five locations) 2016-17

Variety	PH	NSH	TY65	DTM	TNH	TWH	TY95	DM
Cimega	62.2 cd	4.1 cd	25.3 ab	93.6 a	8.6 bc	0.6 a	37.3 a	18.9 b
Farida	62.8 cd	4.4 c	26.3 ab	90.8 ab	8.4 bc	0.5 ab	33.1 b	19.0 b
Jelly	69.9 b	5.2 b	18.7 d	91.9 a	7.2 cd	0.5 ab	29.9 c	19.3 b
Memphis	68.6 b	3.7 d	23.6 b	95.3 a	6.8 d	0.6 a	36.7 ab	19.2 b
Panamrra	75.7 a	4.3 c	25.2 ab	92.8 a	9.1 ab	0.5 a	33.6 b	19.1 b
Taisiya	63.5 c	4.7 bc	21.9 c	91.9 a	10.7 a	0.5 ab	32.7 bc	16.8 c
7four7	56.5 d	4.2 c	28.1 a	94.1 a	9.6 ab	0.6 a	38.7 a	18.6 b
BARI Alu-7 (Diamant)	66.2 bc	6.6 a	17.7 d	91.1 a	9.1 ab	0.4 bc	27.5 cd	19.8 b
BARI Alu-13 (Granola)	57.7 d	4.7 bc	17.1 d	84.1 b	8.4 bc	0.4 c	24.8 e	18.3 b
BARI Alu-25 (Asterix)	65.6 c	5.4 b	17.4 d	91.5 a	9.9 ab	0.4 bc	27.2 cd	19.8 b
BARI Alu-28 (L. Rosetta)	60.4 cd	4.9 bc	17.6 d	84.6 b	7.7 cd	0.4 bc	26.3 de	21.2 a
CV%	8.7	9.9	9.3	8.4	13.1	9.1	9.4	3.8

PH - Plant height at 60 DAP (cm), NSH - Number of stems hill^{-1}, TY65 - Tuber yield at 65 DAP (t ha^{-1}), DTM - Days to tuber maturity, TNH - Tuber number hill^{-1}, TWH - Tuber weight hill^{-1} (kg), TY95 - Tuber yield at 95 DAP (t ha^{-1}), DM - Dry matter (%)

Table 2. Marketable yield (t ha^{-1}) of exotic varieties at 65 DAP as influenced by different environments 2016-17

Genotypes	Bogra	Debiganj	Jamalpur	Munshiganj	Jashore	Mean
Cimega	34.8 abc	34.5 a	10.5 c	18.5 ab	21.5 ab	23.3 ab
Farida	38.6 ab	40.6 a	9.7 c	16.2 abc	22.2 ab	24.3 ab
Jelly	30.6 cd	24.2 cd	7.7 c	12.0 cd	20.0 bc	18.7 d
Memphis	38.3 ab	29.2 bc	12.2 bc	14.6 a-d	17.6 bcd	23.6 b
Panamera	30.0 a	31.9 b	16.2 ab	12.8 cd	22.8 ab	22.2 bc
Taisiya	34.3 bc	28.4 bc	9.8 c	15.2 a-d	17.2 bcd	21.9 c
7four7	39.3 ab	39.6 a	19.8 a	13.6 bcd	25.6 a	28.1 a
BARI Alu-7 (Diamant)	25.3 d	24.0 cd	8.3 c	13.1 bcd	23.1 ab	21.7 c
BARI Alu-13 (Granola)	28.0 d	22.9 d	9.9 c	10.6 d	15.6 d	17.1 d
BARI Alu-25 (Asterix)	29.8 cd	20.0 d	9.5 c	10.2 d	15.2 d	17.4 d
BARI Alu-28 (L. Rosetta)	17.5 e	29.2 bc	7.8 c	20.0 a	18.0 cd	17.6 d
CV%				9.3		

Table 3. Tuber yield (t ha^{-1}) at 95 DAP of the genotypes as influenced by different environments 2016-17

Variety/location	Bogra	Debiganj	Jamalpur	Jashore	Munshiganj	Mean
Cimega	41.4 abc	53.6 ab	12.4 bc	34.6 a	44.6 a	37.3 a
Farida	25.5 fg	57.4 a	14.8 abc	24.5 bc	43.1 a	33.1 b
Jelly	33.9 cde	41.7 c	10.9 bc	21.1 c	42.1 a	29.9 c
Memphis	46.7 a	53.1 ab	18.7 ab	22.5 bc	42.3 a	36.7 ab
Panamrra	42.1 ab	42.9 c	15.3 abc	24.9 bc	42.5 a	33.6 b
Taisiya	37.9 bcd	48.2 bc	12.7 bc	21.6 c	43.1 a	32.7 bc
7four7	43.9 ab	54.9 ab	22.0 a	30.1 ab	42.5 a	38.7 a
BARI Alu-7 (Diamant)	32.2 def	26.9 d	13.2 bc	27.1 abc	38.2 ab	27.5 cd
BARI Alu-13 (Granola)	17.9 g	42.3 c	10.3 c	22.4 bc	30.9 b	24.8 e
BARI Alu-25 (Asterix)	29.3 ef	32.3 d	11.1 bc	23.8 bc	39.7 a	27.2 cd
BARI Alu-28 (L. Rosetta)	30.3 def	31.6 d	10.2 c	21.7 c	37.8 ab	26.3 de
CV%			9.4			

Station average grades of tubers by weight and number are presented in Table 4. Variety Memphis produced the maximum larger-sized tubers. Cimega and 7four7 also produced larger-sized tubers at higher proportion. The check varieties BARI Alu-7, BARI Alu-28, BARI Alu-13 and Taisiya produced more small-sized tubers. Farida and Jelly produced maximum, medium-sized tubers.

Table 4. Average grading of tubers by number and weight (%)

Variety	Tuber Grading by Number					Tuber Grading by Weight				
	<15 mm	15-28 mm	28-40 mm	40-55 mm	>55mm	<15 mm	15-28 mm	28-40 mm	40-55 mm	>55mm
Cimega	7.7	17.1	34.1	36.2	5.0	0.7	5.2	30.3	47.9	16.0
Farida	6.8	16.1	36.3	37.5	3.4	1.2	5.2	33.9	47.2	12.5
Jelly	6.8	14.1	37.0	37.7	4.3	1.3	4.9	32.0	51.7	10.1
Memphis	4.3	17.0	34.9	36.3	7.5	0.4	6.8	28.4	46.2	18.1
Panamrra	6.8	19.3	38.7	31.9	3.3	0.7	7.7	35.9	45.8	9.9
Taisiya	6.6	20.5	37.8	33.8	1.4	1.2	10.3	35.4	49.1	3.9
7four7	7.8	18.2	40.9	28.5	4.6	0.7	5.5	31.5	45.1	17.3
BARI Alu-7 (Diamant)	11.7	23.2	36.8	26.4	1.9	1.4	10.8	36.8	44.1	6.9
BARI Alu-13 (Granola)	7.5	18.8	40.1	31.3	2.2	1.1	7.2	36.2	47.8	7.6
BARI Alu-25 (Asterix)	5.4	22.5	44.7	26.6	0.9	2.8	11.3	42.4	40.9	2.5
BARI Alu-28 (L. Rosetta)	6.3	21.1	35.0	33.5	4.1	1.0	13.1	33.3	48.7	3.9

Dry matter content of the produced tubers is an important character of a variety because it is positively related to the processing quality of the tuber (Leonel et al., 2017). It is also related to the keeping quality of a tuber. Table 5 shows the estimated dry matter content of the tubers. Variation from variety to variety is highly significant. But all the varieties did not behave similar from station to station, which might be due to the sampling error or discrepancies in the methods of estimation. The known high dry matter containing variety BARI Alu 28 produced the highest dry matter at all the stations, the average being 21.2%, while Taisiya produced the lowest (16.8%). All other varieties including checks were medium in dry matter production. Similar results were found in previous studies (TCRC, 2015; TCRC, 2016).

Table 5. Dry matter (%) of the genotypes as influenced by different environments 2016-17

Variety	Bogura	Debiganj	Jamalpur	Jashore	Munshiganj	Mean
Cimega	18.1 ab	18.9 cd	18.9 cd	20.3 bc	18.3 c	18.9 b
Farida	18.5 ab	20.3 abc	20.3 abc	18.1 de	19.2 bc	19.0 b
Jelly	18.1 ab	20.1 bc	20.1 bc	20.5 bc	18.5 c	19.3 b
Memphis	16.8 b	21.6 ab	21.6 ab	19.5 cd	18.7 c	19.2 b
Panamrra	18.7 ab	20.2 bc	20.2 bc	18.7 cde	18.7 c	19.1 b
Taisiya	17.3 b	14.9 e	14.9 e	15.8 f	19.4 bc	16.8 c
7four7	17.6 b	19.0 c	19.1 c	18.6 cde	19.2 bc	18.6 b
BARI Alu-7 (Diamant)	19.7 a	19.2 c	19.2 c	21.7 1	18.7 c	19.8 b
BARI Alu-13 (Granola)	17.8 b	17.1 d	17.1 d	17.4 ef	20.8 ab	18.3 b
BARI Alu-25 (Asterix)	18.3 ab	22.2 a	22.2 a	20.3 bc	18.4 c	19.8 b
BARI Alu-28 (L. Rosetta)	18.1 ab	22.0 ab	22.0 ab	22.6 a	22.2 a	21.2 a
CV%				3.8		

The results of the organoleptic tests of the boiled potatoes are presented in Table 6. Panamera, Memphis, Jelly and Farida were attractive in appearance, but Farida was the best in taste and 2nd in texture. Cimega was not good in taste and texture, though it was very good as yield.

Table 6. Organoleptic test of the potato genotypes

Genotypes	Appearance (Scale 1-5)	Rank	Texture (Scale 1-9)	Rank	Taste (Scale 1-5)	Rank
Cimega	3.5	8	5.5	7	2.8	6
Farida	4.2	4	8.3	2	4.5	1
Jelly	4.5	2	8.5	1	4.3	2
Memphis	4.3	3	5.5	7	2.3	7
Panamera	4.8	1	7.5	4	3.0	5
Taisiya	3.8	7	6.7	6	3.7	4
7 four 7	3.5	9	7.0	5	3.0	5
BARI Alu-7 (Diamant)	4.2	4	8.0	3	4.0	3
BARI Alu-25 (Asterix)	4.2	5	8.0	3	4.0	3
BARI Alu-28 (L. Rosetta)	4.0	6	8.0	3	4.0	3

The most important stage of the multi-environment field trials is to identify high yielding varieties with stable performance across different environments (Karuniawan et al., 2021). From the stability studies (Fig.1 and Fig. 2), it is clear that the variety 7four7 was the most stable among the varieties as its position close to the center of the plot. The variety Cimega is also stable in yield as remains near the center next to 7four7. The variety Taisiya, though is near stable, its yield per area is not as high as those of the preceding two. So, its selection is questionable. The variety Memphis is more responsive to the better environment. This variety seems to be suitable under good management. Among the stations, Debiganj is the most productive, but the performances of the varieties seem to be more reliable at Munshiganj.

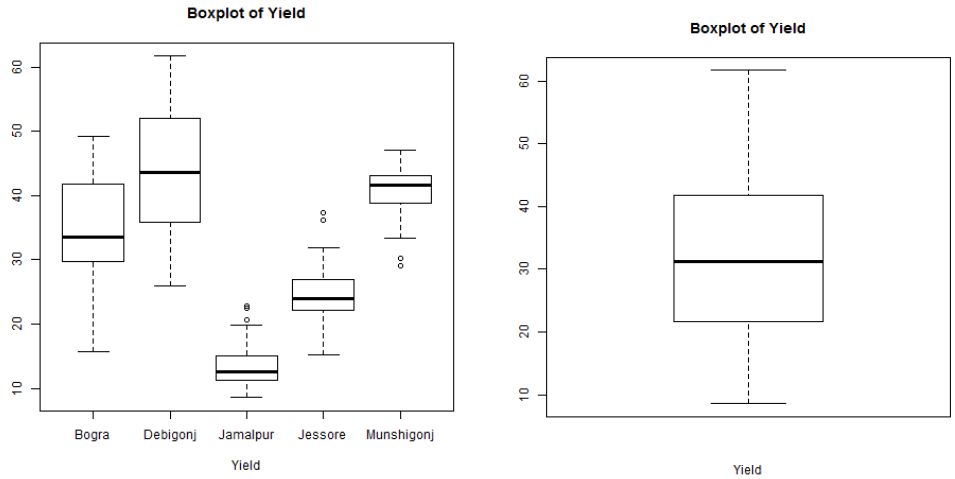

Figure 1. Showing the boxplot of yield of different genotypes of potato

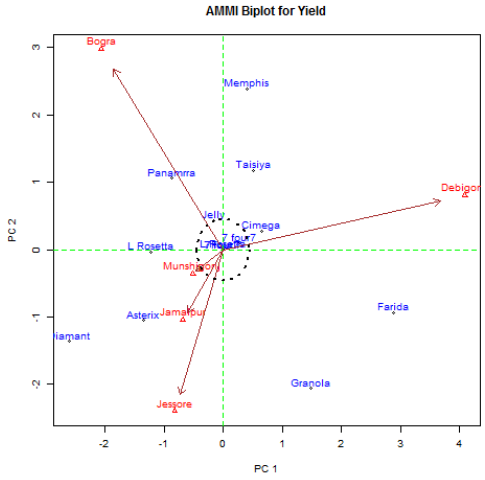

Figure 2. AMMI Biplot (PC1 vs. PC2)

CONCLUSION

From the results of the multi-location trials of this year and also based on the previous years' performances, it can be concluded that the variety 7four7 is the most suitable for early planting. This variety can also be selected as a table potato as it gives very high yield at full maturity. Variety Farida is best suited for table purpose because of its tuber size, shape, color, yield and eating qualities. Varieties Cimega, Panamera and Jelly are also high yielders, but maybe further checked for specific qualities. While Memphis may be tried as a processing variety, as it produces large tubers with good dry matter. Though Panamera is a high yielder, its height should be observed carefully before selecting for a commercial variety.

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Conflict of interest

The authors declare that there is no conflict of interest in this research.

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