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Selection of Exotic Potato Genotypes for Export and Processing Purposes in Bangladesh

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ABSTRACT

Six exotic potato genotypes named Actrice, Cereza, Margarita, Messi, Picobella, and Sunred, along with four check varieties, were evaluated at different locations (agro-ecological region) of Bangladesh in three consecutive years, 2016-17 to 2018-19 respectively to find out some stable genotypes for commercial cultivation in Bangladesh. Combined analysis of variance showed a highly significant difference among the genotypes, locations, and GEI for all the characters studied. None of the genotypes were found suitable for early harvesting (65 DAP), but when the full maturity was considered, significant variations were found for different tuber qualities and yield. During the third year, the mean highest yield was observed in Sunred (39.86 t ha^{-1}), closely followed by Margarita (37.57 t ha^{-1}). All the tested genotypes yielded more than 30 t ha^{-1} and were better than the checks. Dry matter content was the highest in the check variety Lady Rosetta (20.09%). None of the tested genotypes were better than the check varieties in dry matter content, quite unsuitable for processing. Sunred produced a very large-sized uniform and smooth tubers with a medium-high dry matter. If its dry matter content can be increased by 2-3% giving intensive agronomic management, this variety may be suitable for French Fry production. All the exotic genotypes were suitable as table potatoes. Picobella was the most stable, but the average yield is low. Considering the yield and other qualities, Sunred, Margarita, Cereza and Actrice may be further evaluated in large plots for commercial cultivation before releasing as variety.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important tuber crops grown in Bangladesh for its high yield, good nutrition, easy digestibility, and many industrial uses (Haydar et al. 2007). Because of its high yield potential and food value compared to rice and wheat, it is considered a promising candidate crop for feeding the world's hungry people (Hoque et al. 2014). Bangladesh occupies the 6th topmost position in potato production among all the countries of the world. It produces around 10 million tons per year from half a million hectares of land yielding about 20.4 tons per hectare (FAOSTAT 2020). This yield is low compared to that of the high potato producing countries. One of the major factors contributing to the low yield of potato is improved cultivar's inadequacy with wide adaptability and

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stability in tuber yield (Kundu et al. 2020). The second cause is the low investment from the farmers because of the low-price potato at harvest. Farmers sometimes cannot dispose of their potatoes at a reasonable price due to glut in the market. So, the price goes down and farmers face loss, which results in low investment, low yield, and low production. This situation has to be changed through the rapid utilization of potato through export, processing, and consumption (Hussain 2012). But the big problem of export and processing is the quality of the Bangladeshi potatoes. The climatic condition of Bangladesh does not favor good quality tuber production required for export and processing (Akhter et al. 2012; Kundu et al. 2012; Rashid 2014). To produce export and processing quality tubers, not only suitable varieties should be identified, but also tuber quality should be improved through agronomic management.

Potato variety development through hybridization and selection is the regular practice in most potato growing countries. As it is a crop of the cooler region, the long-day condition is required for flowering. But, such a condition does not prevail in Bangladesh. So, variety development through hybridization and selection is a tedious job and takes more time. In that case, to release a variety within a short period through the introduction is skillful. The processes of improvement of potato varieties started from the 1960s by the introduction of high yielding or modern varieties from exotic sources (Siddique et al. 2015). The modern potato varieties have bigger tubers with processing qualities. The imported varieties were evaluated in agro-ecological zones for assessing the desired characters suitable for commercial cultivation under short-day condition in Bangladesh. So, the study was undertaken to evaluate some exotic genotypes over the years under different agro-ecological conditions to identify stable genotypes suitable for export and processing to boost up our national economy and farmer's socio-economic condition.

MATERIALS AND METHODS

The experiment was conducted at six agro-ecological locations (environment) of the country, namely Bogura, Debiganj, Gazipur, Jamalpur, Jashore, and Munshiganj during the Rabi (winter) season of three consecutive years, 2016-17 to 2018-19. Six exotic potato genotypes, namely Actrice, Cereza, Margarita, Messi, Picobella, and Sunred received from different certified sources, and four check varieties BARI Alu-7 (Diamant), BARI Alu-13 (Granola), BARI Alu-25 (Asterix), and BARI Alu-28 (Lady Rosetta) were included in the study. All experiments were laid out in a randomized complete block design (RCBD) with three replications. The unit plot size was 3 m × 3 m. Plant to plant and row to row spacing was 25 cm and 60 cm, respectively. Whole seed tubers were collected and distributed to different experimental locations from Breeder Seed Production Centre, Debiganj, Panchagarh. Well sprouted seed tubers were planted at different locations during the last week of November in the winter season. Manures and fertilizers were applied as per TCRC, BARI recommendation (Kundu et al. 2018). Half of Urea and a full dose of other fertilizers were applied immediately before planting the seed in furrows and mixed properly with the soil. The rest amount of Urea was applied as side-dressing at 35 days after planting. Necessary intercultural operations such as irrigation, weeding, earthing up and plant protection measures were done as per TCRC, BARI recommendation (Kundu et al. 2018). The crop was harvested at 65 and 95 DAP (days after planting). Data were taken on days to start of emergence, emergence percentage at 30 DAP, plant vigor at 60 DAP, foliage coverage at 60 DAP, plant height at 60 DAP, number of stem per hill at 60 DAP, tuber no per hill at 95 DAP, tuber weight per hill at 95 DAP, dry matter percentage at 95 DAP, tuber grading by number & weight, marketable tuber yield at 65 DAP and marketable tuber yield at 95 DAP. Data were analyzed statistically and means were separated by using DMRT through R & RStudio statistical computer program. AMMI was done through R & RStudio statistical computer program (de Mendiburu and de Mendiburu 2020).

RESULTS AND DISCUSSION

Combined analysis of variance showed a highly significant difference among the genotypes, locations (environments), and their interactions (GEI) for all the characters studied (Table 1). This data indicates that there was a presence of high genetic variability among the genotypes and environment for almost all the characters understudied. Therefore, it can be said that potato genotypes responded significantly due to the environmental effects (Tsegaw 2011).

The significant mean interaction effects observed for all the variables are presented in Table 2. The range of days to start emergence was 13.28-15.92 days. The highest mean days to start of emergence was found (15.92 days) in Cereza, whereas the lowest mean (13.28 days) was in Diamant. Emergence % at 30 DAP was good in all the genotypes. The highest mean emergence % was found (76.81) in Diamant, whereas the lowest mean (60.53) was in Picobella. Early emergence is a good character of a variety which helps in early foliar development and less pre-emergence damage of the seed tuber. Plant vigor was good for all the genotypes which indicated the good health of the plants (Lobato et al. 2008). The plant vigor ranged from 4.33 to 9.33 on a scale of 1 to 10, where 1 is

Table 1. Combined analysis of variance (ANOVA) of different characters of potato over six locations during 2018-19

Source of variation	df	MSS					
		DSE	**EP**	**PV**	**FC**	**PH**	**NSH**
Location	5	214.22 ***	16288.5 ***	45.593 ***	1522.61 ***	1749.07 ***	8.3612 ***
Error-I	12	1.46	81.8	1.01	86.17	29.62	1.39
Genotypes	9	28.6198***	1298.23***	12.89***	1706.39***	823.27***	6.0587***
L × G	45	20.89***	1.3000***	5.3005***	846.17***	533.27***	5.34***
Error-II	108	0.7759	51.21	0.4071	51.43	17.08	0.5626
Source of variation	**df**	**MYT65**	**MYT95**	**TNH**	**TWH**	**DM**	
Location	5	1125.61 ***	2121.84***	214.22^{NS}	0.34919**	57.011***	
Error-I	12	486.51	60.34	103.6	0.05638	0.775	
Genotypes	9	336.06***	418.94***	40.02***	0.201902***	58.182***	
L × G	45	145.98***	318.53***	21.663***	0.089235**	20.859***	
Error-II	108	63.97	25.10	10.371	0.045097	0.990	

DSE - Days to start of emergence, EP - Emergence percentage at 30 DAP, PV - Plant vigor at 60 DAP (1-10 scale), FC - Foliage coverage (%) at 60 DAP, PH - Plant height (cm) at 60 DAP, NSH - Number of stem hill^{-1} at 60 DAP, MTY65 - Marketable tuber yield (t ha^{-1}) at 65 DAP, MTY95 - Marketable tuber yield (t ha^{-1}) at 95 DAP, TNH - Tuber no hill^{-1} at 95 DAP, TWH - Tuber wt hill-1 at 95 DAP, DM - Dry matter % at 95 DAP

***Significant at 0.001% level of probability, **Significant at 0.01% level of probability and 'NS' non-significant

the poorest, and 10 is the best. The highest plant vigor was observed (8.64) in Diamant, and the

lowest was (7.06) in Picobella. The average foliage coverage was above 75% in all genotypes except for Picobella. The highest foliage coverage was observed (91.67) in Diamant, and the lowest was (64.94) in Picobella. The variety Picobella gave the highest average plant height (64.31 cm) over the six locations, and the lowest was (51.80 cm) in Lady Rosetta. The highest average number of stems hill^{-1} was performed by Cereza (6.1), but other genotypes also had a good number of stems hill^{-1}. The high number of stems is desirable, because it builds early soil coverage and more photosynthetic area, and also produce more number of tubers per plant (Knowles and Knowles 2006).

At harvest, the average highest number of tuber hill^{-1} (10.27) was found in Diamant closely followed by Asterix and Sunred, whereas the average lowest number of tuber hill^{-1} (5.66) was found with Messi (Table 3). In the case of tuber weight hill^{-1} the average highest weight (0.7 kg) was found in Sunred, and the lowest tuber weight (0.40 kg) was found in Granola (Table 3). Tuber dry matter content is an important characteristic of a variety as it is directly related to processing and storage qualities (Leonel et al. 2017). Considering the average over six locations, check variety Lady Rosetta gave the statistically highest dry matter (20.90%), and the lowest gave Actrice (16.75%)

Table 2. Days to start of emergence, emergence % at 30 DAP, plant vigor at 60 DAP, foliage coverage at 60 DAP, plant height at 60 DAP and number of stem hill^{-1} at 60 DAP of selected potato genotypes as influenced by different environments, 2018-19 (mean interaction effect of six locations)

Genotype/Variety	DSE	EP	PV	FC	PH	NSH
Actrice	15.11 b	70.95 b	7.39 ef	79.33 cde	56.65 c	3.87 c
Cereza	15.92 a	75.14 ab	8.50 ab	86.25 b	63.24 ab	6.10 a
Margarita	14.67 bc	62.04 cd	8.17 bc	81.94 bcd	57.23 c	5.29 b
Messi	14.67 bc	62.78 cd	7.81 cde	76.22 e	57.30 c	3.87 c
Picobella	14.22 cd	60.53 d	7.06 f	64.94 f	64.31 a	4.32 c
Sunred	13.89 d	65.59 c	8.44 ab	80.44 cde	61.49 b	4.13 c
BARI Alu-7 (Diamant)	13.28 e	76.81 a	8.64 a	91.67 a	60.49 b	5.34 b
BARI Alu-13 (Granola)	13.83 de	76.07 a	7.89 cd	78.39 de	49.01 e	5.07 b
BARI Alu-25 (Asterix)	14.50 c	74.48 ab	7.53 de	81.72 bcd	61.57 ab	4.06 c
BARI Alu-28 (L. Rosetta)	13.78 de	72.20 ab	8.00 c	84.06 bc	51.80 d	4.21 c
CV (%)	6.25	10.45	8.13	9.06	7.20	16.66
Level of significance	***	***	***	***	***	***

DSE - Days to start of emergence, EP - Emergence percentage at 30 DAP, PV - Plant vigor at 60 DAP (1-10 scale), FC - Foliage coverage (%) at 60 DAP, PH - Plant height (cm) at 60 DAP, NSH - Number of stem hill^{-1} at 60 DAP

***Significant at 0.001% level of probability

Table 3. Tuber no hill^{-1}, tuber wt hill^{-1} and dry matter percentage of selected potato genotypes as influenced by different environments, 2018-19 (mean interaction effect of six locations)

Genotype/Variety	Tuber no hill^{-1} at 95 DAP	Tuber wt hill^{-1} at 95 DAP	Dry matter (%)
Actrice	7.96 bc	0.56 bc	16.75 f
Cereza	7.83 bcd	0.51 bcd	16.98 ef
Margarita	7.51 bcd	0.51 bcd	17.48 cde
Messi	5.66 d	0.54 bc	17.76 cd
Picobella	6.95 bcd	0.48 cd	16.96 ef
Sunred	8.34 abc	0.70 a	16.87 ef
BARI Alu-7 (Diamant)	10.27 a	0.65 ab	19.23 b
BARI Alu-13 (Granola)	6.49 cd	0.40 d	17.14 def
BARI Alu-25 (Asterix)	8.63 ab	0.53 bcd	18.13 c
BARI Alu-28 (L. Rosetta)	7.96 bc	0.48 cd	20.90 a
CV (%)	39.69	46.33	5.65
Level of significance	***	**	***

***Significant at 0.001% level of probability and **Significant at 0.01% level of probability

(Table 3). None of the imported genotypes was better than the check varieties in dry matter content, which indicated that these varieties are not quite suitable for processing, but may be selected for table use or for export purpose only if other qualities are found good.

Tuber grades by number and weight are presented in Table 4. Larger tubers are needed for both processing and export purposes, while medium sized tubers are desired by local table purpose. Small sized tubers are suitable for seed purpose. In our study, large sized tubers were produced by Sunred and Messi. Genotypes Actrice and Margarita also produced medium to large sized tubers (Table 4). All check varieties produced maximum seed sized tubers. If the keeping qualities of these four genotypes are found good in the further trials, those may be suitable for export purpose.

In order to search for early market (early bulker) genotypes, all the genotypes were harvested partly at 65 DAP (Table 5). During the second year (2017-18), the highest marketable tuber yield was found (27.62 t ha^{-1}) in Messi, which was statistically similar to Margarita, Sunred, Actrice, Hermosa, Picobella, Cereza, and Asterix; the lowest was (18.47 t ha^{-1}) in Lady Rosetta. In the third year (2018-19), Margarita was performed better and gave a significantly higher marketable tuber yield 30.60 t ha^{-1}, whereas the minimum yield gave Picobella 18.39 t ha^{-1}. Margarita gave higher yield in both years at 65 DAP, which can be selected as early bulker. However, all the tested exotic genotypes performed more than 18 t ha^{-1} in both years (Table 5).

The final harvest was done at 95 DAP. All exotic genotypes were gradually adapted to the Bangladeshi climatic condition and gave a higher yield in the following generation compared to the first year (Table 6). Further, yield is a combined outcome of the effects of the genotype (G),

Table 4. Average grading percentage by number and weight of potato of six locations, 2018-19

Genotype/ Variety	% of Tuber Grading by Number				% of Tuber Grading by Weight			
	<28mm	28-40mm	40-55mm	>55mm	<28 mm	28-40mm	40-55mm	>55mm
Actrice	22.43	36.27	33.90	23.15	5.25	22.89	47.23	24.73
Cereza	23.92	21.05	22.93	16.98	5.81	25.32	40.74	10.90
Margarita	26.57	38.81	27.83	23.30	8.72	25.04	44.67	21.87
Messi	22.32	29.66	34.87	21.71	6.7	15.32	44.53	34.08
Picobella	25.53	39.05	28.92	23.38	5.31	32.12	47.75	14.99
Sunred	20.17	31.38	34.52	21.52	3.96	16.08	41.66	38.39
BARI Alu-7 (Diamant)	25.75	45.48	26.21	24.36	8.03	32.59	49.13	10.62
BARI Alu-13 (Granola)	28.35	40.78	29.85	24.74	7.27	36.95	46.79	9.33
BARI Alu-25 (Asterix)	26.35	43.72	26.29	24.09	6.19	35.15	47.63	11.10
BARI Alu-28 (L. Rosetta)	19.44	41.11	34.48	23.75	6.96	29.46	50.35	13.30

Table 5. Marketable tuber yield at 65 DAP of selected potato genotypes as influenced by different environments, 2017-18 to 2018-19 (mean interaction effect of six locations)

Genotype/Variety	**Marketable tuber yield (t ha^{-1}) at 65 DAP**		
	2017-18 (Second year)	**2018-19 (Third year)**	**Mean**
Actrice	23.06 ab	23.81 bc	23.44
Cereza	21.88 ab	22.62 bcd	22.25
Margarita	25.88 a	30.60 a	28.24
Messi	27.62 a	21.51 bcd	24.57
Picobella	21.89 ab	18.39 d	20.14
Sunred	27.15 a	24.33 bc	25.74
BARI Alu-7 (Diamant)	18.51 b	24.83 b	21.67
BARI Alu-13 (Granola)	19.19 b	23.87 bc	21.53
BARI Alu-25 (Asterix)	22.20 ab	19.27 cd	20.74
BARI Alu-28 (L. Rosetta)	18.47 b	19.67 bcd	19.07
CV (%)	15.22	35.52	
Level of significance	***	***	

***Significant at 0.001% level of probability

environment (E) and GE interaction (Gedif and Yigzaw 2014). During the first year (2016-17), Cereza gave maximum marketable yield (28.67 t ha^{-1}), which was statistically similar to Messi (28.43 t ha^{-1}), and Margarita gave minimum marketable yield (20.23 t ha^{-1}). In the second year (2017-18), Cereza gave the highest marketable tuber yield (31.80 t ha^{-1}), which was statistically similar to Messi (31.24 t ha^{-1}), Margarita (30.55 t ha^{-1}), Actrice (29.09 t ha^{-1}), Picobella (26 t ha^{-1}), Sunred (25.11 t ha^{-1}); and Diamant gave the lowest marketable yield (17.54 t ha^{-1}). In the third year (2018-19), Sunred gave maximum marketable tuber yield (39.86 t ha^{-1}), which was statistically similar to Margarita (37.57 t ha^{-1}), and Lady Rosetta gave minimum marketable yield (29.96 t ha^{-1}). But on an average of 2nd and 3rd years, Margarita gave the highest tuber yield.

AMMI described the general genotypic adaptation or stability among genotypes. Some genotypes in one environment exposed higher yield than in other environments. Individual genotype performance can be measured based on their position relative to the X and Y axis. The suitable exotic genotypes are those which have high yield with stable performance over the location. The relative ranking of different genotypes on the biplots is based on its projection on to the XY-axis in AMMI Biplot. The results of the AMMI model analysis are interpreted based on AMMI1 biplot, where the graph is plotted with the main effect and first multiplicative axis term (PC1) for both genotypes and environments. Greater the Principal Component Axis (PC1) scores, either negative or positive, indicated the specific adaptation of a genotype to certain environments. The more the PC1 scores approximate to zero, the more stable the genotype among the environments under study. Results of stability and response of the genotypes for yield under different environments are discussed character-wise as follows (Eberhart and Russell 1966); Stability parameter, i.e., regression coefficient (bi), and deviation from regression (S^2di) of the individual genotypes for tuber yield at 95 DAP are presented in Table 7. Regression coefficient (bi) was considered as a parameter of the response of the genotype to different environment. In addition, deviation from regression

Table 6. Marketable tuber yield at 95 DAP of selected potato genotypes as influenced by different environments, 2016-17 to 2018-19 (mean interaction effect of six locations)

Genotype/Variety	**Marketable tuber yield (t ha^{-1}) at 95 DAP**		
	2016-17 (First year)	**2017-18 (Second year)**	**2018-19 (Third year)**
Actrice	27.13 b	29.09 a-d	35.14 bc
Cereza	28.67 a	31.80 a	36.02 b
Margarita	20.23 g	30.55 abc	37.57 ab
Messi	28.43 a	31.24 ab	31.86 cd
Picobella	26.06 c	26.00 a-e	30.05 de
Sunred	27.28 b	25.11 a-e	39.86 a
BARI Alu-7 (Diamant)	27.48 b	17.54 f	35.58 b
BARI Alu-13 (Granola)	24.85 d	23.22 c-f	27.60 e
BARI Alu-25 (Asterix)	25.33 d	24.20 b-f	34.60 bc
BARI Alu-28 (L. Rosetta)	22.10 f	20.77 ef	29.96 de
CV (%)	4.70	15.25	15.35
Level of significance	***	***	***

***Significant at 0.001% level of probability

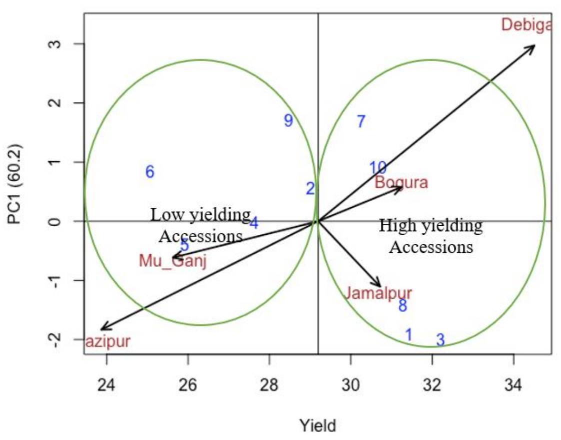

Figure 1. Biplot of the first AMMI interaction (IPCA1) score (Y-axis) plotted against mean yield (X-Axis) of potato yield at 95 DAP and different environments during 2016-17 to 2018-19
(1-Actrice, 2-Cereza, 3-Margarita, 4-Messi, 5-Picobella, 6-Sunred, 7-Diamant, 8-Asterix, 9-Lady Rosetta, 10-Granola)

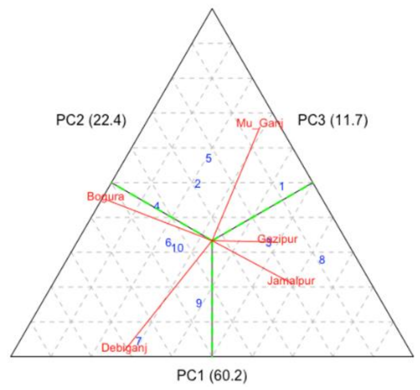

Figure 2. AMMI 1 triplot for yield (ton ha^{-1}) of 10 potato genotypes using genotypic and environmental scores during 2016-17 to 2018-19
(1-Actrice, 2-Cereza, 3-Margarita, 4-Messi, 5-Picobella, 6-Sunred, 7-Diamant, 8-Asterix, 9-Lady Rosetta, 10-Granola)

(S^2di) was used as the index of stability. (Eberhart and Russell, 1966) proposed "regression coefficient" (bi) to evaluate genotype adaptability and "regression deviation" (S^2di) to evaluate the stability, which indicates the probability of the genotypes to deviations in the environment (Rios et al. 2009).

According to AMMI1 biplot, the PC1 scores for both genotypes and environments were plotted against the mean yield at 95 DAP for genotypes and the environments (Figure 1). In the biplot, the broken vertical line passing through the center of the biplot was the grand mean of the potato yield. The biplot showed two groupings of genotypes: Actrice, Margarita, Diamant, Granola, Asterix were high yielding but Cereza, Messi, Picobella, Sunred, Lady Rosetta were low yielding. Further, Bogura, Debiganj and Jamalpur weather favors potato production. On the other hand, Munshiganj and Gazipur respond negatively for higher yield (Figure 1).

Greater the Principal Component Axis (PC1) scores, either negative or positive, indicated the specific adaptation of a genotype to certain environments. The more the PC1 scores approximate to zero, the more stable the genotype among the environments under study. When the IPCA1 was plotted against IPCA2, Mehari et al. (2015) pointed out that the closer the genotypes score to the center of the biplot the more stable is the genotype and the reverse is true.

Guei et al. (2005) suggested that the first three principal components are often the most important in reflecting the variation patterns among accessions. The PCA revealed three main principal component representing 94.3% of total variance among the ten genotypes (Figure 2). The AMMI biplot, which accounted for 93.57% of the G x E interaction, provides the interaction principal

Table 7. Principal component score along with stability parameters for total yield at 95 DAP during 2016-17 to 2018-19

Genotype/Variety	Yield	PC1	PC2	PC3	PC4	bi	S^2di	ASR
Actrice	31.43	-1.91	0.31	0.05	0.61	0.13	1.28	4.75
Cereza	32.21	-1.99	-1.34	-0.41	-0.21	0.38	8.61	5.50
Margarita	30.27	1.69	-1.87	-0.36	-0.02	1.88	4.13	7.00
Messi	31.28	-1.42	-0.43	1.66	-0.32	0.52	5.90	4.00
Picobella	28.47	1.71	-0.08	1.35	-0.13	1.71	3.86	6.75
Sunred	30.86	0.91	0.16	-0.06	-0.09	1.36	0.73	2.25
BARI Alu-7 (Diamant)	27.63	-0.02	-0.03	-1.55	-1.02	1.12	3.27	5.75
BARI Alu-13 (Granola)	25.92	-0.38	1.49	-0.47	0.51	0.63	1.44	4.56
BARI Alu-25 (Asterix)	29.02	0.57	1.68	0.17	-0.95	1.14	14.40	8.75
BARI Alu-28 (L. Rosetta)	25.07	0.84	0.10	-0.37	1.62	1.13	1.49	5.31
Bogura	31.25	0.64	0.15	-2.33	-0.60			
Debiganj	34.51	3.30	-0.60	0.85	0.50			
Gazipur	23.87	-2.04	-1.16	-0.20	1.52			
Jamalpur	30.72	-1.23	-1.15	1.03	-1.56			
Munshiganj	25.63	-0.68	2.75	0.66	0.13			

component scores of the 1st and 2nd IPCA.

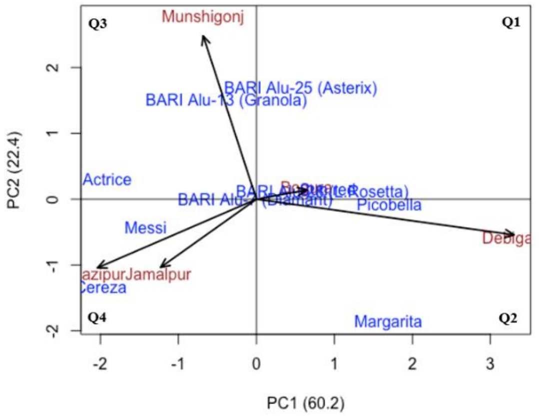

Figure 3. AMMI Biplot 2 interaction (IPCA1 and IPCA2) of potato yield 95 DAP and different environments during 2016-17 to 2018-19

Using potato tuber yield at 95 DAP, the PCA grouped genotypes into four main clusters (Figure 3). According, genotype Actrice, Cereza, Margarita, Messi, Sunred, BARI Alu-13 and BARI Alu-25 were unstable as they were located far apart from the other genotypes in the biplot when plotted on the IPCA1 and IPCA2 scores. The genotype located near to the origin of the biplot which implies that they were Picobella, BARI Alu-7, BARI Alu-28 stable across the environments. Potato genotypes Sunred, BARI Alu-7, BARI Alu-28 were positively interacting at Bogura (located at Q1 quadrant) environment. The genotype Picobella, Margarita (located at Q2 quadrant) positively interact at Debiganj.

Greater the Principal Component Axis (PC1) scores, either negative or positive, indicated the specific adaptation of a genotype to certain environments. The more the PC1 scores approximate to zero, the more stable the genotype among the environments under study.

A model genotype could be described as one which was the uppermost yielding across tested environments and is utterly stable in its performance (Yan and Kang 2002). It was observed that the genotype Lady Rosetta was close to the ideal genotype, followed by Diamant, Sunred, Messi respectively. Hassanpanah and Hassan (2014) also found three superior clones with good quantity and quality traits were determined among eighteen promising potato clones in Ardabil province of Iran. BARI Alu-25, Margarita, Picobella, BARI Alu-7, Sunred were selected based on the average sum of ranks. Average sum of ranks (ASR), is an important parameter which rank the genotypes based on a significance test along with the regression coefficient (bi) following Pour-Aboughadareh et al (2019).

Yan and Tinker (2006) also find the most responsive genotypes have the longest distance from the origin of the biplot. The genotypes nearer to originate were the most stable genotype. This indicated that there was a difference in ranking orders among genotypic yield performances across environments leading to crossover G × E interaction (Figure 4). This result was corroborated by reports of Regis et al. (2018).

CONCLUSIONS

At 65 DAP, some exotic genotypes performed better than the checks, but not exactly suitable for early harvesting. Considering marketable yield potentiality at 65 DAP, Margarita can be selected as an early variety. At final harvesting (full maturity), considering the marketable yield potentiality, Sunred, Margarita, Cereza, and Actrice were suitable for maincrop varieties as commercial cultivation due to its higher tuber yield potentiality at 95 DAP harvesting. Variety Sunred produces very large sized uniform and smooth tubers, its dry matter is medium high, if its dry matter content can be increased up to 20 or 21% giving intensive agronomic management, this variety may be suitable for French Fry production. All the exotic genotypes can be selected for table potato purposes. These genotypes should be tested further in large plots at on-station and on-farm for confirmation.

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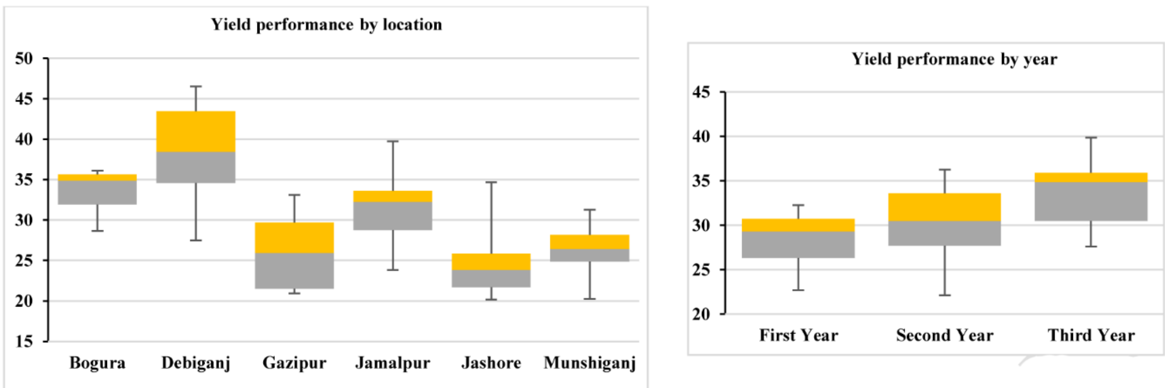

Figure 4. Yield performance at 95 DAP (t ha^{-1}) of ten potato genotypes at different environments during 2016-17 to 2018-19

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CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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