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Characterization and Variability Studies of the Local Small Size Potato (*Solanum* sp.) Genotypes under Sub-Himalayan Foothills of India

Riman Saha Chowdhury* and Suchand Datta

Dept. of Vegetable and Spice Crops, Uttar Banga Krishi Viswavidyalaya (UBKV), Pundibari, Coochbehar, W.B. (736 165), India

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Corresponding Author

Riman Saha Chowdhury

e-mail: riman.saha03@gmail.com

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Abstract

An experiment was conducted with twenty five small size potato (*Solanum sp.*) genotypes to characterize the different growth, yield and quality characters as well as its variability. The research work was conducted at the Instructional farm of the Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, and West Bengal, India during the year 2017-18 and 2018-19. The experiment was laid out in randomized block design with tree replications The genotypes were characterized for 37 characters namely, tuber characters, sprout and stem characters, leaf characters and growth habit. These genotypes upon sorting showed discrete variation with respect to vegetative, tuber and quality characters. Wide range of variation was also pragmatic among the genotypes for quite a few morphological, tuber and quality characters. Among the different tuber characters absence of secondary tuber colour, shallow depth of tuber, intermediate note of eyes per tuber, evenly distributed eye showed 100% frequency and other leaf and growth characters also shows higher frequency. Variability studies were bare that there was an extensive range of inconsistency for all the characters studied. High GCV and PCV were found in case of anthocyanin content of tuber and yield of tuber plant^{-1}. High heritability along with high genetic advance (as percentage of mean) was found in tuber yield plant^{-1}and average weight of single tuber. These characters may be painstaking as trustworthy selection indices as they are possibly governed by additive gene effect.

Keywords: Potato, Characterization, variation, GCV, PCV, Heritability

1. Introduction

Cultivated Potato and their wild relatives are belongs to the family of Solanaceae and the genus is *Solanum*, which is one of the largest genus comprise with approximately 1,500 to 2000 species (Anonymous, 2014). From the genus *Solanum* only 1000 species are recognized till date both tuber forming and wild relatives (Burton, 1989). The cultivated potato is considered to be originated from South America and it is introduced in India by Portuguese at the end of 17th century (Keeps, 1979 and Mahgoub et al., 2015). Later on the species acclimatized with the different agro-climactic region of India and cultivated in long scale.

Small size potato tubers are highly acclimatized with the climate with north eastern hill region and terai agro-ecological region. According to the consumer preference this crop fetch higher price in the market, not only that this crops have delicious taste also after cocking. The higher price and unavailability throughout the year is one of the main

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problems of the small size potato to the consumer. The reason behind the problem is unavailability of quality planting material with high yielding varieties to the farmers. The climatic condition favours the cultivation of small potato but cultivation is restricted due to lack of suitable improved varieties and improved production technologies. In the northern parts of west Bengal, there are two types (round shaped and nut shaped) of small sized potato are gown. These potatoes having the higher morphological differences than the normal cultivated potato with this demand of this potato increased day by day due its special characters for preparation of different food items in the changing food habit. It is mostly grown in this region apart from the some other northern parts of the West Bengal, North eastern states like Meghalaya and Manipur. Generally local indigenous varieties are planted by the farmers of this region but difficult to judge which one is superior in term quality. Desirable parental combinations provide the basis for selection in the follow up hybrid breeding process for exploitation of heterosis (Thul et al., 2009).Information regarding the precise morphological and biochemical study is quite lacking. Since plant breeding and cultivar improvement are essential parts of improving nourishment creation, in this manner, accessibility of and access to different hereditary sources will guarantee that the worldwide nourishment generation arrange turns out to be progressively practical (Jat et al., 2019). According to Thakur et al. (2018) information and magnitude of genetic variability, divergence are directly and indirectly effect on yield by its component traits is significant to plan the systematic breeding programme. Arslanoglu et al. (2011) reported that local potato genotypes are significant types in terms of their maturity period, disease resistance and tolerance against environmental stress factor. To initiate any breeding work, it is necessary to assess the genetic variability present in the indigenous genotypes for yield and its components (Desai and Jaimini (1997), Chaudhary (1985) and Datta and Das., 2013). For the assessment of appropriate potato genotypes, hereditary parameters (Luthra et al., 2005, Joseph et al., 2005 and Barik, 2007) and characters affiliation gives data about anticipated that reaction of different characters should help in creating reasonable rearing strategy for their enhancement for nature and greatness of inconstancy in the current plant material (Rangre and Rangre, 2017). All the above mentioned circumstance keeps in mind the present experiment was undertaken to study the characterization and variation of the small size potato genotypes.

2. Materials and Methods

The present experiment was conducted at the Instructional farm of the Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, and West Bengal, India. Geographically the experimental field is situated at $26^0$19'86" N latitude and $89^0$23'53" E longitude, at an elevation of 43 meter above mean sea level with an objective of characterization of collected genotype of small size potato tuber. Twenty five genotypes were collected from different areas of the terai agro-ecological region of West Bengal, Sikkim and Assam (Table 1). These genotypes were evaluated in with three replications during the *rabi* (winter) season of 2017-18 and 2018-19. The weather stipulation of terai zone is sub-tropical humid in nature characterized by high rainfall, high relative humidity, moderate temperature, lengthened winter with high enduring soil moisture. The experimental soil was sandy clay loam having pH 5.6. The soil contains 0.91% organic carbon, 133.78 kg ha^{-1} available nitrogen, 45.72 kg ha^{-1} available phosphorus and 59.35 kg ha^{-1} available potash. Healthy and disease free tubers are shown in plots of 3.60×3.0 m^2 size with a spacing of 30×20 cm^2 during middle of November. Organic manure @ 20 t $ha^{-1}$was applied as basal. Inorganic fertilizers were applied @150: 60: 120 kg ha^{-1} N: P_2O_5: K_2O. Full dose of P_2O_5, half dose of K_2O and half of nitrogen was given as basal dose at the time of land preparation. After 45 days of sowing top dressing was done with half of nitrogen and rest halfK_2O. Observations on different morphological and phenotypic characters were recorded from ten randomly selected plants from each replication. By using the descriptor list of IBPGR for potato the characterization for most of the characters was done on ten randomly selected plants from each replication (Mackay et al. 1985) and the frequency percentages are evaluated. Burton (1952) was given the formula for calculating the genotypic and phenotypic coefficient of variation (GCV and PCV, respectively), which was used here for calculating GCV and PCV. By using the formula of Jhonson et al. (1955) the heritability in broad sense was calculated. Depending on the Allard (1960) formula the Genetic advance were calculated for the different characters under study.

3. Results and Discussion

3.1. Characterization

An extensive range of deviation was recorded between the genotypes of several morphological characters. The genotypes were characterized by red and white cream predominant tuber skin colour and the majority of genotypes showed red skin (84%). Abong et al. (2010) was reported most of the Kenya cultivars showed white, cream and red colour skin present on different genotypes under their experiment. In the case of secondary tuber skin colour, only one genotype was showed white cream colour on the skin over the red with 4% frequency and the distribution of the colour are shows in splashed manner. The general tuber skin type was varies from smooth to rough and the rough skin was dominant over smooth skin (38%). In the present experiment, the predominant tuber flesh colour the small size potato tubers was differed from white to yellow and majority of tuber shows yellow-cream colour (76%) followed by yellow flesh colour (12%). Similar finding was reported by Rahaman et al. (2017) in Bangladesh condition. Along with the predominant tuber flesh colour some secondary colour red (60%) also present in

Table 1: Genotype Details of the collected genotypes of small size potato

Genotype No.	Country	State	District	Locality	Latitude	Longitude
G1	India	West Bengal	Coochbehar	Pundibari	26°24'30.3"N	89°23'01.6"E
G2	India	West Bengal	Coochbehar	Pundibari	26°24'30.3"N	89°23'01.6"E
G3	India	West Bengal	Kalimpong	Kalimpong	27°04'14.7"N	88°28'24.6"E
G4	India	West Bengal	Kalimpong	Teesta Market	27°03'24.8"N	88°25'27.7"E
G5	India	West Bengal	Darjeeling	Naxalbari	26°40'57.2"N	88°12'00.4"E
G6	India	West Bengal	Jalpaiguri	Rajganj	26°33'47.6"N	88°31'18.3"E
G7	India	West Bengal	Jalpaiguri	Maynaguri	26°33'42.6"N	88°49'29.7"E
G8	India	West Bengal	Jalpaiguri	Dhupguri	26°35'20.0"N	89°00'34.1"E
G9	India	West Bengal	Alipurduar	Tufanganj	26°18'55.9"N	89°40'06.6"E
G10	India	West Bengal	Coochbehar	Daoanhat	26°08'45.7"N	89°27'47.5"E
G11	India	West Bengal	Alipurduar	Birpara	26°28'53.1"N	89°30'23.9"E
G12	India	West Bengal	Coochbehar	Ghoksadanga	26°25'17.9"N	89°16'39.4"E
G13	India	West Bengal	Coochbehar	Ghoksadanga	26°25'17.9"N	89°16'39.4"E
G14	India	West Bengal	Alipurduar	Jateswar	26°36'20.5"N	89°08'39.2"E
G15	India	West Bengal	Coochbehar	Mekhligang	26°20'36.9"N	88°54'40.0"E
G16	India	Assam	Jorhat	Assam	26°43'29.1"N	94°11'44.8"E
G17	India	West Bengal	Coochbehar	Ghughumari	26°19'59.6"N	89°19'41.1"E
G18	India	West Bengal	Alipurduar	Chalsa	26°52'44.9"N	88°47'53.8"E
G19	India	Sikkim	Gangtok	Gangtok Market	27°19'39.8"N	88°36'42.9"E
G20	India	West Bengal	Darjeeling	Darjeeling Market	27°02'31.6"N	88°15'52.4"E
G21	India	West Bengal	Jalpaiguri	Ambari	26°08'59.4"N	89°24'30.2"E
G22	India	West Bengal	Alipurduar	Jaigaon	26°50'37.0"N	89°22'51.9"E
G23	India	West Bengal	Alipurduar	Hassimara	26°42'00.3"N	89°22'43.0"E
G24	India	Nagaland	Dimapur	Dimapur Market	25°54'41.3"N	93°43'17.7"E
G25	India	West Bengal	Jalpaiguri	Haldibari	26°20'07.1"N	88°46'49.0"E

the flesh of the potato tuber, which was distributed in the flesh by a broad vascular ring (56%) and scattered (4%) manner. The genotypes were shows five types of general tuber shape namely round, ovate, long oblong, oblong, compressed and oblong. Among the tuber shapes, the round and ovate shape of tuber individually take 28% and the rest of the genotypes shows 12% in a long oblong shape, 4% in compressed and oblong shape. Pandey et al. (2009) reported most of the cultivar under their experiment shows round and ovate type of tuber, along with this shape are good for chips making purpose. Some unusual tuber forms were also found in the tuber which was clavate (8%), reniform (4%), fusiform (4%) and flattered (8%). Shallow depth of the eye predominant in all the tubers understudy, which findings also supported by Rahaman et al. (2017) and Kabira and Lamega (2006) also refers shallow to medium-deep eyes were liked by the consumers. Mostly intermediate note of eyes present in per tuber with 100% frequency. Tuber setting parentage found higher in 60% of the genotypes followed by medium (28%) and all the tuber size are small with 100% frequency. Tuber defects likely crack, scar, hollow heart, internal necrosis etc. are fully absent (100%) in the genotypes under study, which finding supported by Rahaman et al. (2017). Majority of the genotypes was showed low (56%) uniformity in the tuber size followed by medium (44%) uniformity in tuber size. Long stolon length (56%) found dominant over the medium (28%) and short (12%) among the small potato genotypes within the experiment and the genotypes take medium weeks (100%) to harvest of the tuber (Table 2). The sprout and stem characters were collected among the genotypes according to the descriptor of potato which showed remarkable variation in the genotypes under study (Table 3). The red colour of sprout (40%) was showed dominant over the white-green (36) and pink colour (24%), no secondary sprout colour and their distribution was present in the genotypes. Among the genotypes, 17 number of genotype was showed green colour stem with 68% frequency and eight genotypes showed red-brown colour with 32% frequency. Arslanoglu et al. (2011) was worked on local potato genotypes

Table 2: Tuber Characters of the small size potato genotypes according to potato descriptor

Tuber Characters				
Character	Types	Descriptor code	No. of genotype	Frequency (%)
Predominant tuber skin colour	Red	6	21	84
	White cream	1	4	16
Secondary tuber skin colour	Absent	0	24	96
	White–cream	1	1	4
Distribution of Secondary Tuber Colour	Absent	0	24	96
	Splashed	3	1	4
Tuber skin type	Smooth	1	7	38
	Rough	2	18	72
Predominant tuber flesh colour	white	1	2	8
	Cream	2	1	4
	Yellow –Cream	3	19	76
	yellow	4	3	12
Secondary Tuber Flesh Colour	Absent	0	10	40
	Red	5	15	60
Distribution of Secondary Tuber Flesh Colour	Absent	0	10	40
	Scattered Area	2	1	4
	Broad Vascular Ring	4	14	56
General tuber shape	Round	2	7	28
	Ovate	3	7	28
	Elliptic	5	1	4
	Long Oblong	7	3	12
	Compressed	1	1	4
	oblong	6	4	16
Unusual tuber forms	Absent	0	19	76
	Clavate	2	2	8
	Reniform	3	1	4
	Fusifrom	4	1	4
	Flattered	1	2	8
Depth of eye				
	Shallow	2	25	100
Note of eyes per tuber	Intermediate	5	25	100
Distribution of tuber eyes	Evenly distributed	2	25	100
Tuber Set	High	7	15	60
	Low	3	3	12
	Medium	5	7	28
Tuber Size	Small	3	25	100
Tuber Defects				

Table 2: Continue...

Tuber characters				
Character	Types	Descriptor code	No. of genotype	Frequency (%)
Crack	Absent	0	25	100
Secondary growth	Absent	0	25	100
Hollow heart	Absent	0	25	100
Internal Necrosis	Absent	0	25	100
lenticels	Absent	0	25	100
Uniformity of Tuber Size	Low	3	14	56
	Medium	5	11	44
	Stolon Length	Short	3	4
	Medium	5	7	28
	Long	7	14	56
Weeks To Harvest	Medium	5	25	100

Table 3: Sprout and stem charactersof the small size potato genotypes according to potato descriptor

Sprout and Stem Characters				
Character	Types	Descriptor code	Number of genotype	Frequency (%)
Predominant Sprout Colour	White-green	1	9	36
	Pink	2	6	24
	Red	3	10	40
Secondary Sprout Colour	Absent	0	25	100
Distribution of Secondary Sprout Colour	Absent	0	25	100
Stem Color	Green only	1	17	68
	Red-brown only	2	8	32
Stem Cross Section	Round	1	6	24
	Angular	2	19	76
Stem Wing	Absent	0	3	12
	Straight	1	11	44
	Undulate	2	11	44
Number of primary stem	Few	2	8	32
	Medium	5	10	28
	Many	7	7	60

and found a similar type of findings in their research work. Majority of the stems found angular (76%) in shape when the stem cross-section was done followed by a round stem (24%). Stem wing one of the important character for characterization the genotypes, which showed in straight (44%) and undulated (44%) manner among the experimental genotypes. Primary stem found majority amid the genotypes with 60% frequency followed by few (32%) and medium (28%) (Figure 1 and 2).

Leaf and growth habit characters were also found helpful for characterizing the genotypes under the experiment. A weakly dissected leaf was mostly found in case of 19 genotypes with 76% frequency and medium dissected found only 6 genotypes with 24% frequency. Glabrescent

Figure 1: Different small size potato germplasm plant

Figure 2: Different small size potato germplasm tuber

type of abaxial leaf pubescence (72%) was found dominant over normal pubescence (28%) and all the genotypes show simple types of hairs (Trichomes) with 100% frequency. Majority of the genotypes was showed erect (84%) type of growth habit followed by semi-erect (12%) and decumbent (4%) with 100% branching habit (Table 4). High variability in morphological characters in local potato genotypes was reported by Anoumaa et al. (2017) and Arslanoglu et al. (2011), which could be selected and identified for inclusion in potato breeding programme.

Table 4: Leaf characters and growth habitof the small size potato genotypes according to potato descriptor

Character	Types	Descriptor code	Number of genotype	Frequency (%)
Leaf characters				
Leaf dissection	Weakly Dissected	4	19	76
	Medium Dissected	5	6	24
Abaxial leaf pubescence	Glabrescent	1	18	72
	Pubescence	2	7	28
Type of hairs (Trichomes)	Simple	1	25	100
Growth habit				
Character	Types	Descriptor code	Number of genotype	Frequency (%)
Growth habit type	Erect	1	21	84
	Decumbent	3	1	4
	Semi-erect	2	3	12
Branching habit	Branching	2	25	100

3.2. Genetic variability

The data on genetic advance as % mean(GAM), phenotypic coefficient of variation (PCV), range, genotypic coefficient of variation (GCV), mean and heritability in broad sense (H^2) of different character have been accessible in Table 5. It is apparent from the above table there was a wide range of variability for all the characters on condition that an ample scope for selecting desirable types. Maximum range was observed in tuber number plant^{-1} (67.94-22.82) followed by plant height (66.97-22.98 cm), anthocyanin (98.11-1.87 mg 100 g^{-1}), etc.

The estimation of GCV and PCV were recorded for most of the characters indicated that contribution towards final phenotypic expression of the characters was mostly by genetic architecture of the genotype rather than environmental factors reported by Mehta and Asati (2008) and Sharavati et al. (2018). The above findings were also supported by the findings of Choudhary and Samadia (2004) in chilli. It was apparent that

Table 5: Range, mean and genotypic and phenotypic coefficient of variation, heritability and genetic advance of the different characters of small potato genotypes

Characters	Range	Mean	GCV	PCV	Heritability	GA (%)of mean
Plant height (cm)	66.97-22.98	35.31	20.76	21.93	0.89	40.46
Sprout tuber^{-1}	17.55-6.24	11.93	22.31	23.17	0.93	44.25
Compound leaf plant^{-1}	13.73-4.16	7.87	23.59	25.30	0.87	45.32
Stem diameter	8.26-3.22	7.51	5.15	25.69	0.04	2.13
Anthocyanin	98.11-1.87	30.61	78.11	78.15	0.99	160.85
Number of tuberplant^{-1}	67.94-22.82	49.18	23.45	23.75	0.97	47.12
Average weight tuber^{-1}	10.58-3.02	4.97	31.39	31.69	0.98	64.05
Yield plant^{-1}	339.63-77.63	162.47	34.91	34.99	0.99	71.76

the higher enormity of GCV observed in anthocyanin content of the tuber (78.11%), followed by yield plant^{-1} (34.91%), etc. Desai and Jaimini (1997), Chaudhary (1985) and Regassa and Basvaraj (2010) are also reported similar type of finding after their experiment conducted. The GCV was always lower than corresponding PCV for most of the characters denote environmental factors concluded by Haydar et al. (2009). In present study highest PCV also observed in anthocyanin content of tuber (78.15%) and tuber yield plant^{-1} (34.99%), which is similar to the finding of Mondal et al. (2007). Except

plant height, compound leaf plant^{-1} and stem diameter, the rest characters was showed more than 90% heritability. Similar trends in for heritability along with correlation coefficient for potato was also recorded by (Luthra et al., 2005, Joseph et al., 2005, Barik, 2007 and Barik et al., 2010). Haydar et al. (2009) reported highest heritability was observed for the tuber yield plant^{-1} and suggested that selection for these characters are effective and improvement is made through phenotypic selection. Phenotypic performance of the above character found more reliable for estimating higher heritability between the characters of the genotypes under study. Additive gene effect may be playing the pioneer role in estimation of higher heritability (Narayana et al., 1996). So, these characters could be measured as trustworthy selection indices and selection on the basis of these characters might be worthwhile. For selecting desirable character among the genotypes high genetic advance play one of the key role along with very high heritability among the genotypes. But for better comparison of GA was converted to GA as % of mean. High heritability estimates united with high predictable GA as % of mean were pragmatic in case of anthocyanin content of tuber, yield plant^{-1} and average weight of single tuber (Table 5). Haydar et al. (2009) also reported similar findings in their study on potato genotypes. Heritability estimate with GA% are further helpful in predict yield under phenotypic selection than heritability alone according to Mondal et al. (2007) in potato. Therefore, these characters could be painstaking as reliable selection indices and selection on the basis of these characters might be gratifying.

4. Conclusion

Yield plant^{-1} and weight of single tuber having the high heritability as well as high genetic advance as percentage. Therefore, these characters could be reliable selection indices and selection on the basis of these characters might be rewarding for the future breeding programme.

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