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Genetic Variability Studies in Potato (*Solanum tuberosum* L.) Genotypes for Growth, Yield and Processing Quality Traits

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Abstract

The study was conducted to assess the extent and nature of genetic variability, heritability and genetic advance among the different thirty five potato genotypes for growth, yield and processing quality attributes over two seasons during *kharif* and *rabi*-2021. Results of analysis of variance revealed significant differences among the potato genotypes for different parameters. For all the characteristics evaluated, phenotypic coefficients of variation were higher than genotypic coefficients of variation. The phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) were found high for weight of tubers per plant (g), tuber shape, number of branches and marketable tuber yield. Range of variability for most of the traits was found high, which indicated ample scope for selection and improvement in these traits. Further, high heritability estimates coupled with genetic advance were recorded for parameters such as plant width, plant height, weight of tubers per plant and marketable tuber yield which revealed the presence of additive gene action in expression for these characters. Thus variability, heritability and genetic advance in combination provide a clear picture regarding the effectiveness of selection for improving the characters. Hence, this information in identified genotypes and traits could be used for future potato breeding programs.

Keywords : Potato, Phenotypic coefficients of variation (PCV), Genotypic coefficients of variation (GCV), Heritability, Genetic advance

Potato (*Solanum tuberosum* L.) is the fourth most important crop in the world after wheat, maize and rice and its contribution towards securing the food, nutrition, avoiding the poverty and hunger, especially in developing world, where food is perpetually on demand to feed the increasing populations. Potatoes are considered as a non-fattening, nutritious and wholesome food, which supply important nutrients to the human diet. Potato protein is superior to that of cereals and rich in essential amino acid lysine and vitamin C (Chethan, *et. al.,* 2020). It can supplement the food needs of the country in a substantial way. Besides its significance to human food security, potato is also a crop with fascinating genetic traits and cultural history. The potato genome contains 12 chromosomes and 860 million base pairs, making it a medium-sized plant genome The present day cultivated potatoes (tetraploid; 2n=4x=48) in most of the world represent *Solanum tuberosum* subsp. *tuberosum* and *S. tuberosum* subsp. *andigena*.

In India, about 68 per cent of tubers are utilized for table purpose, 7.5 per cent for processing; 8.5 per cent for seed and remaining 16 per cent produce go as waste due to pre and post-harvest handling. Moreover, cold stores can accommodate only about 65 per cent of produce, which leads to huge wastage of potatoes.

The crop is mainly grown during winters in Indo-Gangestic plains and accounts to nearly 90 per cent production of the country. The major potato producing states are Uttar Pradesh, West Bengal, Bihar, Gujarat, Punjab, Madhya Pradesh, Assam and Haryana. There is a great scope for cultivation of potato suitable for processing and it has opened a new dimension for development of agro-based industries in the country. However, certain morphological, bio-chemical and physico-chemical attributes are necessary in potato varieties to meet the requirement for processing.

Breeding of potato is a cumbersome task due to inherent genetic and biological factors. However, the genetic advance helps to assess the extent of advancement that could be made through selection (Annigeri *et al*., 2022). Genetic variability estimates in conjunction with heritability and genetic advance gives a clear idea of scope of improvement through selection. Genetic analysis reveals the genetic nature of the inheritance of tuber yield and yield components which is required to design effective potato crop improvement. Therefore, the study was conducted with the objective to assess the extent and nature of genetic variability, heritability and genetic advance among the different potato genotypes for growth, yield and quality traits.

Material and Methods

Field experiment was conducted to evaluate different thirty five potato genotypes suitable for processing quality traits with economic yield for two seasons during both *kharif*-2021 and *rabi*-2021 at Horticulture Research and Extension Centre, Hassan, Karnataka (Plate 1). An experiment was laid out in Randomized Complete Block Design with two replications. Thirty five genotypes *viz*., AICRP- P-60, AICRP- P-61, AICRP- P-57, AICRP- P-74, AICRP-P-77, AICRP- C-1, AICRP- C-8, AICRP- C-10, AICRP- PH-3, AICRP- C-11, AICRP-C-23, AICRP-P-24, AICRP-P-43, AICRP-P-79, AICRP-P-53, AICRP-P-56, AICRP-C-29, AICRP-RH-2, AICRP-P-72, AICRP-C-13, AICRP-C-20(check), AICRP-C-24 (check), AICRP-C-17, AICRP-P-73, AICRP-P-81, AICRP-P-14, AICRP-P-1, CYT-1, CYT-2, Patna-1, Patna-2, FC-1, FC-3, FC-5 and FL were evaluated in the study. The land was prepared for the research well before planting by deep summer ploughing and incorporating FYM @ 25 t/ha into the soil followed by rotovator to break the soil clods. The tuber planting was taken up during both seasons by adopting scientific spacing of 60 cm x 20cm with 3 m X 3 m plot size. The recommended dosage of NPK @ 75:75:100 kg/ha was incorporated. From the recommended quantity of nitrogen, 50 per cent of nitrogen applied at the time of planting and remaining 50 per cent of nitrogen after 30 days after planting at earthing-up operation. The recommended package of practices was followed during different stages of crop growth to till harvesting. The observations related to vegetative growth, yield and quality attributes were recorded as follows.

Vegetative Growth Parameters

Germination (%), plant height (cm), number of leaves, number of branches per plant and the plant spread in North to South and East to West were

Plate 1: Field view and plot view of experiment conducted during *kharif* 2021

recorded. The number of days taken from the date of sowing to till harvest of each variety was counted and was considered as time taken for physiological maturity.

Yield Parameters

The number of tubers per plant and weight of tubers per plant were documented. Out of total tubers obtained in a plant, the tubers were sorted out into marketable tuber yield (>25 g) and unmarketable tuber yield (0-25 g). Total tuber yield was computed by adding marketable tuber yield and unmarketable tuber yield.

Processing Quality Traits

Shape and Size of the Tuber

Size of the tuber length and width were noted (Plate 2). The tuber sample was scored for shape as per the scale by Wooster and Farooq, 1995.

Plate 2 : Evaluation for tuber quality traits

Dry Matter Content (%)

The dry matter content was determined by hot air oven method.

Tuber Firmness (kg/cm²)

The firmness of the tubers was determined by using digital penetrometer

Reducing Sugars (%)

Sugars present in the samples were estimated by following the method outlined by Lane and Eynon described by Ranganna (1977)

Extraction and Determination of Starch Content

The residue after extraction for sugar was washed several times with distilled water to ensure that there was no more soluble sugar in the residue. After that, following the procedure of Kang *et al*. (2009) starch content was estimated (Plate 3).

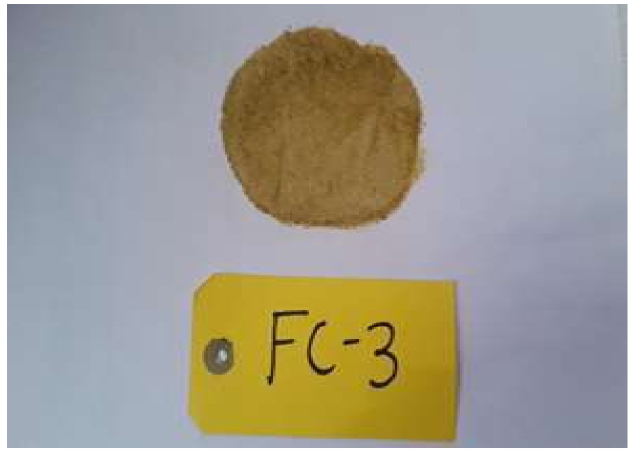

Plate 3 : Extraction of Starch

Statistical Analysis

Analysis of variance, the genotypic (GCV) and phenotypic (PCV) coefficient of variations, heritability and genetic advance (GA) and genetic advance mean (GAM) were computed using SAS software.

RESULTS AND DISCUSSION

Analysis of variance (ANOVA) showed highly significant differences among the genotypes for growth, yield and tuber quality parameters evaluated (Table 1). High variability among the various traits was observed in the genetic variability study. The estimates of PCV for all the characteristics was greater than the estimates of GCV (Table 2). The highest estimates of coefficients of variations was recorded for weight of tubers per plant (g) (GCV=42.38%; PCV=42.65%), followed by tuber shape (GCV=38.74%; PCV=39.74%), number of branches (GCV=25.17%; PCV=34.16%), marketable tuber yield (GCV=24.84%; PCV=27.42%) and total tuber yield (GCV=19.79%; PCV=22.96%). Lowest estimates of coefficients of variations were observed for reducing sugars (per cent), plant emergence (per cent) and maturity parameters.

TABLE 1

Analysis of variance for growth, yield and quality traits in potato genotypes

Characters	Mean sum of squares		
	Replication (df=3)	Genotypes (df=34)	Error (df=102)
Plant Emergence (%)	151.69	96.63 **	10.60
Plant height (cm)	31.91	491.90 **	7.12
Plant width EW (cm)	84.27	451.62 **	4.32
Plant width NS (cm)	28.86	450.98 **	5.20
No. of branches	0.54	1.46 **	0.25
No. of leaves	2.71	170.29 **	4.25
Maturity (No. of days)	14.00	284.91 **	22.05
No. of tubers per plant	0.48	9.71 **	2.75
Weight of tubers per plant (g)	149.48	37234.08 **	118.72
Total yield (t/ha)	15.39	45.13 **	3.62
Marketable yield (t/ha)	5.04	52.95 **	2.74
Tuber length	0.26	4.83 **	0.43
Tuber width	0.36	1.44 **	0.11
Tuber shape (1-9 scale)	0.26	9.66 **	0.12
Tuber firmness (kg/cm^2)	5.88	114.21 **	2.03
Dry matter (%)	0.62	20.72 **	1.62
Reducing sugar (%)	6.65	6.81	6.73
Starch (g)	1.25	182.39 **	0.34

*Significant at 5% level; **Significant at 1% level

The observed higher estimates of phenotypic and genotypic coefficients of variation for above characters, indicates the existence of adequate variability among the different potato genotypes for these traits. However, presence of narrow difference between phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) in some of the traits indicated lower environmental influence (Mariyappan *et al.,* 2022). Thus, simple selection could be helpful for bringing further improvement. Similar results were recorded for number of tubers per plant (Sattar *et al.,* 2007) marketable yield (Gunjan, 2008), total tuber yield and weight of tubers (Asefa *et al.,* 2016) in potato genotypes.

Heritability

The estimates of heritability (broad sense) varied for various parameters (Table 3). The maximum heritability for weight of tubers per plant (98.74 %) followed by plant width EW (96.28%), Plant width NS (95.54%), tuber shape (95.03%), plant height (94.45%) tuber firmness (93.24%) and marketable tuber yield (82.06%). Moderate heritability was observed for number of branches (54.30%) followed by number of tubers per plant (38.80%) parameters, while, low estimates of heritability was present for reducing sugars (9.10%). The observed high heritability values are in consonance with the earlier workers for the characters *viz.,* for tuber yield, plant height and weight of tubers per plant (Luthra *et al.,* 2001).

Genetic Advance (GA) and Genetic Advance Mean (GAM)

The highest genetic advance was recorded for plant height (22.04), plant width EW (21.37), plant width NS (21.26) and weight of tubers per plant (19.70). Marketable tuber yield recorded (6.61) and total tuber yield (5.71) GA values. The lowest genetic advance value was observed for number of branches (0.83).

TABLE 2

Mean, coefficient of variation, for various characters of potato genotypes

Characters	Mean	Range		Variance		Coefficient of Variation	
		Min	Max	GV	PV	GCV	PCV
A1	83.79	67.80	96.00	21.51	32.11	5.53	6.76
A2	71.58	40.00	94.00	121.19	128.31	15.38	15.82
A3	52.72	35.00	79.00	111.82	116.15	20.06	20.44
A4	50.70	28.20	77.00	111.44	116.65	20.82	21.30
A5	2.18	1.00	3.75	0.30	0.56	25.17	34.16
A6	39.96	24.00	55.00	41.51	45.76	16.12	16.93
A7	92.03	72.00	120.00	65.71	87.76	8.81	10.18
A8	7.40	2.00	12.00	1.74	4.49	17.83	28.62
A9	227.27	65.00	388.00	9278.84	9397.56	42.38	42.65
A10	16.28	7.30	25.00	10.38	14.00	19.79	22.99
A11	14.26	5.00	22.00	12.55	15.30	24.85	27.43
A12	6.35	3.90	11.00	1.10	1.53	16.52	19.47
A13	4.89	3.00	6.30	0.33	0.44	11.75	13.63
A14	3.99	1.00	8.00	2.38	2.51	38.74	39.74
A15	48.10	36.00	63.80	28.05	30.08	11.01	11.40
A16	20.63	16.00	27.00	4.77	6.40	10.59	12.26
A17	0.50	0.17	31.00	0.02	6.75	3.54	4.56
A18	17.20	58.00	82.50	45.51	45.85	9.45	9.48

Note: A1- Plant Emergence (%), A2- Plant height (cm), A3- Plant width EW (cm), A4- Plant width NS (cm), A5-No. of branches, A5-No. of branches , A6-No. of leaves, A7-Maturity (No. of days) A8- No. of tubers per plant,A9- Weight of tubers per plant (g), A10-Total yield (t/ha), A11-Marketable yield (t/ha) A12-Tuber length, A13-Tuber width, A14- Tuber shape (1-9 scale) A15-Tuber firmness (kg/cm^2), A16-Dry matter (%), A17- Reducing sugar (%) and A18- Starch (%)

These observed results on high genetic advance are in line with previous researchers for the characters like plant height (Sidhu and Pandita, 1979), tuber weight per plant (Ambrish, 2007) and weight of tubers per plant and leaf area (Rahman, 2015) in potato.

Maximum genetic advance mean was observed for plant height (30.86), plant width EW (29.93), plant Width NS (29.76) weight of tubers per plant (27.60) and maturity (20.23). However, moderate GAM values were recorded for marketable tuber yield (19.26), total tuber yield (18.00) and number of leaves (17.70). Lowest GAM mean value was documented for number of branches (1.17). These results are in line with works of Luthra *et al*. (2001) for height of the plant, number of leaves average tuber weight and total tuber yield.

Over all, high heritability estimates coupled with genetic advance were registered for the characters like plant width EW, plant width NS, plant height, weight of tubers per plant and marketable tuber yield per hectare. It reveals the presence of additive action in the expression of these traits which are found more crucial for potential selection.

It can be concluded from the results of the present study that the phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) were high for weight of tubers per plant, tuber shape, number of branches, marketable tuber yield and total tuber yield. Further, high heritability estimates coupled with genetic advance were recorded for parameterssuch as plant width, plant height, weight of tubers per plant and marketable tuber yield which

TABLE 3

Heritability, genetic advance and genetic advance as percent of mean for various characters of potato genotypes

Characters	Heritability (%)	GA	GAM
Plant Emergence (%)	66.99	7.82	10.95
Plant height (cm)	94.45	22.04	30.86
Plant width EW (cm)	96.28	21.37	29.93
Plant width NS (cm)	95.54	21.26	29.76
No. of branches	54.30	0.83	1.17
No. of leaves	90.71	12.64	17.70
Maturity (No. of days)	74.88	14.45	20.23
No. of tubers per plant	38.80	1.69	2.37
Weight of tubers per plant (g)	98.74	19.70	27.60
Total yield (t/ha)	74.12	15.71	18.00
Marketable yield (t/ha)	82.06	16.61	19.26
Tuber length	72.05	11.84	12.57
Tuber width	74.31	11.02	11.43
Tuber shape (1-9 scale)	95.03	3.10	4.34
Tuber firmness (kg/cm2)	93.24	10.53	14.75
Dry matter (%)	74.64	3.89	5.44
Reducing sugars (%)	9.10	2.02	3.06
Starch (g)	10.25	13.85	19.38

Note: GA- Genetic Advance, GAM-Genetic Advance mean

revealed the presence of additive gene action in expression of these characters. This information in identified genotypes and traits could be used for future potato breeding programs. Thus, variability, heritability and genetic advance in combination provide a clear picture regarding the effectiveness of selection for improving the characters.

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