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Variability studies in potato (*Solanum tuberosum* L.) hybrids for yield attributing characters

Radhika Rathore, Pravin Kumar Sharma, Vandana Yadav and Eram Fatima Khan

Abstract
The present study was conducted at Research cum Demonstrational Farm, College of Agriculture, IGKV, Raipur (C.G.) during *Rabi* season of 2020-21. The experiment consisting of ten hybrids of potato was laid under Randomized Block Design (RBD) with three replications. The analysis of genetic variance revealed that the sufficient variability were present in experimental material. The phenotypic coefficient of variance (PCV) was slightly higher in magnitude than genetic coefficient of variance (GCV) for all the parameters revealing influence of environment in expression. The heritability estimates recorded to be high for the characters *viz.* number of leaves plant-1, seed weight plot-1, plant height, number of shoots plant-1, total tuber yield ha-1 and marketable tuber yield ha-1. The moderate genetic advance was recorded for the characters namely marketable tuber yield ha-1, number of tubers plant-1, total tuber yield ha-1, plant height and number of leaves plant-1 revealed that both the additive and non-additive variance are operating in these traits.

Keywords: Potato, genetic variability, GCV, PCV, heritability, genetic advance

Introduction
After rice and wheat, potato (*Solanum tuberosum* L.) is the world's third most consumed crop. It is a member of the solanaceae family. There are around 2000 species in the *solanum* genus, although only about 10% of them bear tubers. In nature, cultivated potato genotypes are tetraploid, with a genome structure of 2n = 4x = 48. The crop has both a high nutritional value and a high yield potential. In India, potatoes are generally consumed as fresh potatoes, with the majority of the harvest consumed domestically, whereas in advanced countries, table potato consumption is just 31%, with the remainder consisting of frozen French fries (30%), chips and shoestrings (12%) and dried products (12%). The presence of variability in a trait is a need for heritable improvement. For any systematic breeding programme to undertake, knowledge of the nature and degree of variability present in a population due to genetic and non-genetic sources is essential. The factor that has an impact on the expression of distinct traits is frequently strong enough to influence the yield in a specific direction. As a result, determining the differential effect of multiple genetic and environmental factors on the expression of a certain yield attributing characteristic is unavoidable. As a result, the current study was conducted to determine genetic variability, heritability, and genetic advance for main yield component features in potatoes.

Materials and Methods
The field experiment was conducted during the *Rabi* season of year 2020-21 at the Research cum Demonstrational Farm of Department of Vegetable Science, Indira Gandhi Krishi Vishwavidyalaya, Raipur situated in the central part of Chhattisgarh, agro climatologically known as “Chhattisgarh Plains” and lies between 21o16 N latitude and 81o26 E longitude at altitude of 289.56 meters above the mean sea level (MSL). The experiment was laid out in randomized block design (RBD) with three replications and plot size of 3.6m× 2m. The seed tubers obtained from the experimental material of All India Coordinated Research Project on Potato, CPRI, Shimla (H.P) were planted on ridges spaced at 60 cm and intra-row spacing of 20 cm on 15th November, 2020. Fully decomposed farmyard manure (FYM) @20 t ha-1 was incorporated and ploughed into the field before planting. The recommended dose of fertilizer *i.e.*150:100:100 kg NPK ha-1 was applied. The whole amount of P and K and half of the N were applied as basal dose. The remaining quantity of N was given in two splits at 30 and 45 days after planting, respectively.

Operations of weeding, earthing up, plant protection and irrigation were performed as per recommendation and when required. Data on yield and yield attributing characters were recorded from 5 randomly selected plants in each plot.

Characters recorded

Ten hybrids of potato were evaluated for different characters *viz*., seed weight plot-1 plant emergence per cent, plant height, number of leaves plant-1, number of shoots plant-1, fresh weight of shoots plant-1, dry weight of shoots plant-1, number of tubers plant-1, tuber girth (cm), tuber length (cm)**,** fresh weight of tubers plant-1, dry weight of tubers plant-1, harvest index per cent, marketable tuber yield ha-1, unmarketable tuber yield ha-1 and total tuber yield ha-1.

Statistical methods

The hybrids, on the basis of the data obtained were studied for the presence of genetic variability through estimation of genetic coefficient of variability (GCV), phenotypic coefficient of variability (PCV), heritability, genetic advance and genetic advance as percentage of mean using the following formulae:

Genotypic and phenotypic coefficient of variation

Genotypic and phenotypic coefficient of variation was calculated by using the following formula proposed by Burton (1952) [5].

$$GCV\ \% = \frac{\sqrt{\sigma 2g}}{\overline{X}}$$

$$PCV\ \% = \frac{\sqrt{\sigma 2g}}{\overline{X}}$$

Where, X = general mean for the character under consideration. The estimates of PCV and GCV were classified as low (< 10%), moderate (10-20%) and high (> 20%) as per classification given by Sivasubramanian and Madhavamenon (1973) [24].

Heritability

Heritability in broad sense (h2b), defined as the proportion of the genotypic variance to the total variance (phenotypic variance) was estimated by using the formula given by Hanson *et al.* (1956) [13].

$$h2bs\ \% = \frac{\sigma 2g}{\sigma 2p} X\ 100$$

The broad sense heritability estimates were classified as low (>50%), moderate (50-70%) and high (<70%) as suggested by Robinson (1966) [18].

Genetic advance

Expected genetic advance was predicted through the method of Johnson *et al.* (1955) [14] at 5 per cent selection intensity.

Genetic advance = $K.\sigma p.h^2$

Where,

K = Constant value of 2.06 at 5% selection intensity.

σp = Phenotypic standard deviation of the character.

h2 = Heritability of the character.

Genetic advance as percent of mean

Genetic advance as percentage of mean was calculated as per formula given by Comstock *et al*., (1952):

$$GA\ as\ percentage\ of\ mean = \frac{GA}{X} \times 100$$

Where,

GA = Genetic advance.

X = Mean.

The magnitude of genetic advance as percentage of mean was classified as low (<25%), moderate (25-40%) and high (>40%).

Result and Discussion

The phenotypic and genotypic coefficient of variance, heritability, genetic advance and genetic advance as percentage of mean was calculated for all the fourteen characters as given in Table 1 and Table 2.

Coefficient of variation

The result obtained showed that phenotypic coefficient of variance was in general higher than the genotypic coefficient of variance for all the characters (Figure 1). It is due to presence of substantial influence of environmental factors besides the genetic variation for expression of these traits.

At 75DAP the moderate magnitude of GCV and PCV (10-20 per cent) were observed for number of tubers plant-1 (17.63 and 21.25 per cent, respectively) followed by marketable tuber yield t ha-1 (16.93 and 18.70 per cent, respectively), dry weight of shoots plant-1 (16.07 and 24.68 per cent, respectively), total tuber yield t ha-1 (15.06 and 16.40 per cent, respectively), fresh weight of shoots plant-1 (14.91 and 20.09 per cent, respectively), plant height (14.59 and 15.67 per cent, respectively), fresh weight of tuber plant-1 (12.75 and 16.61 per cent, respectively), number of leaves plant-1 (12.58 and 12.50 per cent, respectively), plant emergence percent (12.14 and 15.97 per cent, respectively) and number of shoots plant-1 (11.64 and 12.61 per cent, respectively). The low magnitude GCV (<10 per cent) was also observed for the character seed weight plot-1 (8.86 and 9.27 per cent, respectively), tuber girth (6.22 and 8.93 per cent, respectively), tuber length (5.49 and 9.57 per cent, respectively) and harvest index percentage (2.73 and 6.19 per cent, respectively).

The above findings indicate that the characters with moderate magnitude of GCV and PCV *viz.;* number of tubers plant-1, marketable tuber yield t ha-1, dry weight of shoots plant-1, total tuber yield t ha-1, fresh weight of shoots plant-1, number of leaves plant-1, plant emergence percent, number of shoots plant-1 indicates the existence of some variability in the population for these characters at 75 DAP. Therefore, selection for the above traits can also be beneficial for improvement.

These findings are in accordance with the findings by Singh *et al*. (2015) [23] and Ahmad *et al.* (2005) [1] found for number of compound leaves plant-1; Dayal *et al.* (1972) [9] and Chaudhary *et al.* (1984) [8] for total tuber yield; Sharma (1999) [20] for dry weight of shoots plant-1; Bhagowati (2002) [3] for number of leaves plant¹; Basavaraj *et al.* (2005) [2] for fresh weight of tubers plant¹; Kumar *et al.* (2005) [15] for plant height. The moderate GCV and PCV were reported by Luthra

et al. (2005) [17] and Shashikamal (2006) [21] for fresh weight of shoots plant and plant height. Chandrakar (2007) [6] recorded moderate variability for plant height and average tuber yield plant whereas; Singh (2008) [22] reported maximum GCV and PCV percentage for marketable tuber yield plot-1.

Table 1: Estimates of Genotypic and Phenotypic coefficient of variation (GCV and PCV)

S. No.	Parameters	Mean	Coefficient of variance (%)	
			Genotypic	Phenotypic
1.	seed weight/ plot	6.24	8.86	9.27
2.	plant emergence%	85.08	12.14	15.97
3.	plant height (cm)	41.68	14.59	15.67
4.	Number of leaves	110.53	12.58	12.90
5.	number of shoots	15.15	11.64	12.61
6.	fresh weight of shoots plant (gm)	114.13	14.91	20.09
7.	dry weight of shoots plant (gm)	23.18	16.07	24.68
8.	Tuber girth (cm)	15.52	6.22	8.93
9.	Tuber length (cm)	9.07	5.49	9.57
10.	Number of tubers plant-1	7.68	17.63	21.25
11.	Fresh weight of tuber plant-1 (gm)	273.14	12.75	16.61
12.	Marketable tuber yield (t ha)	15.30	16.93	18.70
13.	Harvest index (%)	70.50	2.73	6.19
14.	Total tuber yield (t ha-1)	18.11	15.06	16.40

Heritability and Genetic advance

The estimate of heritability in broad sense and genetic advance calculated for all the fourteen characters is presented in Figure 2 and results are explained below:

At 75 DAP estimate of heritability was recorded high for the character number of leaves plant-1 (95.11 per cent) followed by seed weight plot-1 (91.38 per cent), plant height (86.73 per cent), number of shoots plant-1 (85.10 per cent), total tuber yield t ha-1 (84.29 per cent), marketable tuber yield t ha-1 (82.00 per cent). The character such as number of tubers plant-1 (68.84 per cent), fresh weight of tubers plant-1 (58.93 per cent), plant emergence percentage (57.72 per cent) and fresh weight of shoots plant-1 (55.06 per cent) exhibited the moderate heritability. However, low heritability was observed tuber girth (48.61 per cent), dry weight of shoots plant-1 (42.41 per cent), tuber length (32.85 per cent) and harvest index percentage (19.45 per cent).

High heritability recorded for numbers of leaves plant-1, seed weight plot-1, plant height, number of shoots plant-1 total tuber yield t ha-1 and marketable tuber yield t ha-1 indicated that these characters are less influenced by environmental fluctuations and governed by the additive gene effects that are substantially contributing towards the expression of these traits. However, rest of the traits seems to be governed by non-additive gene effects. Hence, selection for these traits will lead to accumulation of more desirable genotypes.

The present findings on heritability are in accordance with findings reported by the various workers *viz*. Singh (2008) [22] for number of leaves plant-1, plant height, marketable tuber weight plot-1, total tuber weight plot-1, number of tubers plant-1 and dry matter content of tubers. Barik (2007) for fresh weight of shoots plant-1, harvest index per cent, unmarketable yield plot-1, tuber dry matter plant-1, per cent emergence, total number of leaves plant-1, fresh weight of tuber plant-1, total tuber yield plot-1, plant height and dry weight of shoots plant-1, similarly other workers also resulted in the heritability for different traits, Chandrakar (2007) [6], Basavaraj *et al.* (2005) [2], Biswas *et al.* (2005) [4], Bhagowati *et al.* (2002) [3], Luthra (2001) [16], Desai and Juimini (1997) [10], Dixit *et al.* (1994) [11], Chaudhary and Sharma (1984) [8] and Gaur *et al.* (1978) [12] reported mostly high heritability for various component traits in potato.

The moderate genetic advance at 75 DAP observed in characters namely marketable tuber yield t ha-1 (31.58 per cent), number of tubers plant-1 (30.14 per cent), total tuber yield t ha-1 (28.48 percent), plant height (27.99 per cent) and number of leaves plant-1 (25.27 per cent). These findings of moderate genetic advance suggest that both the additive and non- additive variance are operating in these traits However, the low genetic advance as per cent of mean was observed for the character fresh weight of shoots plant-1 (22.79 per cent), number of shoots plant-1 (22.11 per cent), dry weight of shoots plant-1 (21.56 per cent), fresh weight of tuber plant-1 (20.16 per cent), plant emergence (18.99 per cent), seed weight plot-1 (17.45 per cent), tuber girth (8.94 per cent), tuber length (6.48 per cent), harvest index (2.48 per cent). This indicates significance of non-additive gene effects.

Table 2: Estimates of Heritability, Genetic Advance and Genetic Advance as % of mean

S. No.	Parameters	Heritability (H2b) %	Genetic advance K=20.6	Genetic advance as % of mean
1.	Seed weight/plot	91.38	1.09	17.45
2.	Plant emergence%	57.72	16.16	18.99
3.	Plant height (cm)	86.73	11.67	27.99
4.	Number of leaves	95.11	27.93	25.27
5.	Number of shoots	85.10	3.35	22.11
6.	Fresh weight of shoots plant (gm)	55.06	26.01	22.79
7.	Dry weight of shoots plant (gm)	42.41	5.00	21.56
8.	Tuber girth (cm)	48.61	1.39	8.94
9.	Tuber length (cm)	32.85	0.59	6.48
10.	Number of tubers plant-1	68.84	2.32	30.14
11.	Fresh weight of tuber plant-1 (gm)	58.93	55.07	20.16
12.	Marketable tuber yield (t-1 ha)	82.00	4.83	31.58
13.	Harvest index (%)	19.45	1.75	2.48
14.	Total tuber yield (t ha-1)	84.29	5.16	28.48

The moderate genetic advance was recorded for the characters namely marketable tuber yield t ha-1, number of tubers plant-1, total tuber yield t ha-1, plant height and number of leaves plant-1 at 75 DAP. Hence selection for these traits will be worthwhile for improving potato. In agreement to the above results, similar findings were also supported by Choudhary and Sharma (1984) [8] for tuber yield, whereas, Sharma (1999) [20] for fresh weight of tuber plant-1, Luthra (2001) [16] for tuber yield, Luthra *et al.* (2005) [17] for tuber yields, Roy and Singh (2006) [19] for tuber yields and dry matter of percentage and Kumar *et al*. (2005) [15] for tuber yield, Barik (2007) for unmarketable tuber yield, dry weight of tubers plant-1 and total tuber yield, Singh (2008) [22] marketable tuber yield, total tuber yield, weight of tubers plant', number of marketable tubers ha-1, number of leaves plant-1 and number of tubers plant-1.

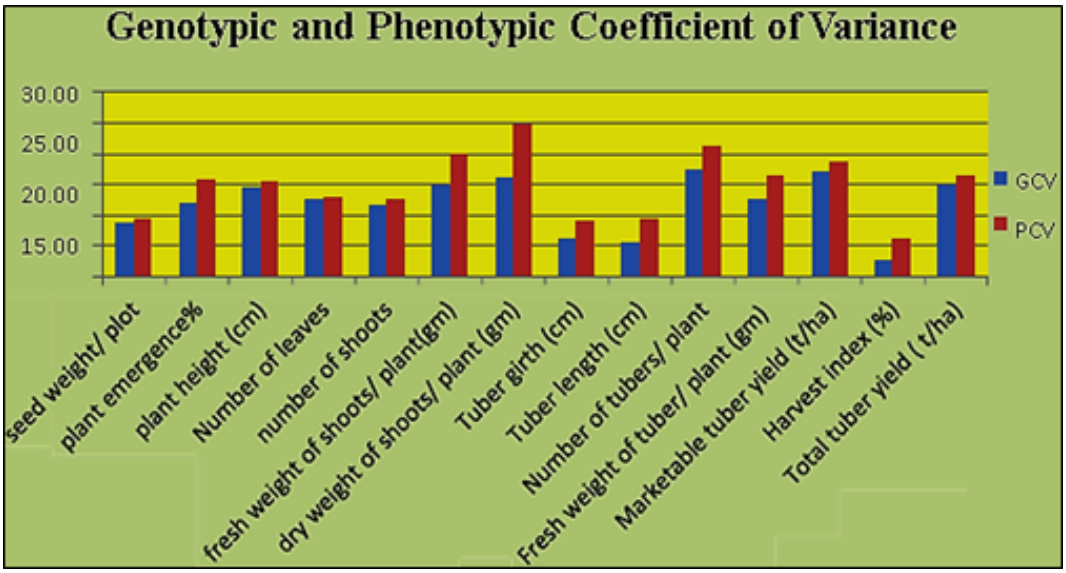

Fig 1: Graphical presentation of Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) for tuber yield and its components

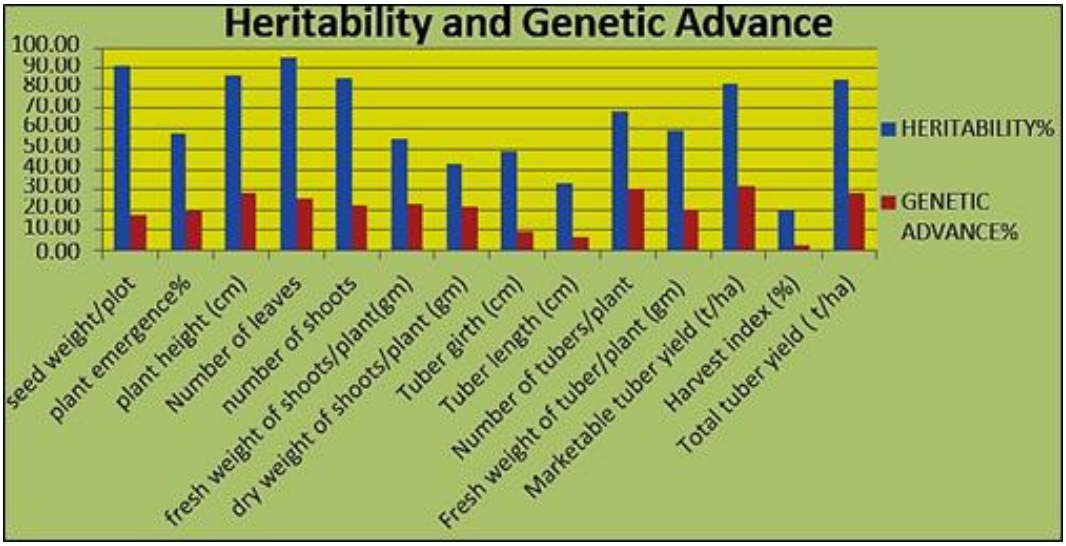

Fig 2: Graphical presentation of Genetic Advance (%) and Heritability % of tuber yield and its components

Conclusion

The phenotypic coefficient of variance (PCV) was slightly higher in magnitude than genotypic coefficient of variance (GCV) for all the characters studied which suggests that the variation is not only due to genotypes but also by influence of environment up to some extent. The estimate of heritability at 75 DAP revealed that characters namely number of leaves plant-1, seed weight plot-1, plant height, number of shoots plant-1, total tuber yield t ha-1 and marketable tuber yield t ha-1 were recorded with high heritability. The high genetic advance as percentage of mean was recorded for marketable tuber yield t ha-1, number of tubers plant-1, total tuber yield t ha-1, plant height and number of leaves plant-1 indicate that these characters are governed by additive gene effect and are less influenced by environment and hence, selection for these characters, if found positively associated with yield will be beneficial in improvement of potato, whereas hybridization or heterosis breeding may be exploited for improvement of the characters with low genetic advance as per cent of mean.

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