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Studies on Parameters of Genetic Variability for Yield and its Attributing Traits in Potato (*Solanum tuberosum* L.)

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The present investigation was undertaken to estimate genetic variability, heritability and genetic advance for important yield component characters in potato. The analysis of variance indicated the existence of sufficient amount of variability among genotypes for all the characters .The phenotypic variance was in general higher than the genotypic variance. Among different yield attributing characters studied, number of compound leaves plant^{-1} had the highest magnitude of PCV (30.96 per cent) and GCV (27.94 per cent). The estimates of heritability revealed that characters namely, dry weight of tubers plant^{-1} followed by number of compound leaves plant^{-1}, marketable tuber yield plot^{-1}, total tuber yield plot^{-1} and fresh weight of tubers plant^{-1} were recorded with high heritability. The highest genetic advance as percentage of mean was recorded for number of compound leaves plant^{-1}, dry weight of tubers plant^{-1}, marketable tuber yield plot^{-1}, total tuber yield plot^{-1} and fresh weight of shoots plant^{-1}. High heritability coupled with high genetic advance was recorded for the traits *viz.* number of compound leaves plant^{-1}, dry weight of tubers plant^{-1}, marketable tuber yield plot^{-1} and total tuber yield plot^{-1}. Hence, these characters were predominantly governed by additive gene action and can be improved through simple selection.

Keywords: Potato, Genetic Variability, GCV, PCV, Heritability, Genetic advance.

Potato (*Solanum tuberosum* L.), because of its great utility, occupies a pre-eminent place amongst the Vegetable crops and therefore, is acknowledged as the "King of Vegetables". Potato is an important food crop and ranks fourth in importance globally next to rice, wheat and maize. The crop has high nutritional value as well as great yield potential. It is an essential crop and has received great attention in the recent past, as it has the ability to produce maximum quantity of produce within minimum time and with use of minimum resources. The existence of variability in a population for particular trait is an important prerequisite for its heritable improvement of the crop. Knowledge of variability present in the population due to genetic and non genetic factors facilitates to develop an appropriate and systematic breeding programme as it provides information about the expected response of

various characters towards selection. The effect of environment on expression of various characters is often pronounced enough to affect the yield in a particular direction. Thus, it is quite inevitable to determine the distinct effect of various genetic and environmental factors on the expression of a particular yield attributing trait. Therefore, present investigation was undertaken to estimate genetic variability, heritability and genetic advance for important yield component characters in potato.

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MATERIALS AND METHODS

The field experiment was conducted during the *rabi* season of year 2015-16 at the Research and Instructional 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 21°16 N latitude and 81°26 E longitude at altitude of 289.56 meters above the mean sea level (MSL). The experiment was laid out in randomized complete block design (RCBD) with three replications and plot size of 2.4 m x 2.4 m. 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 16th November, 2015. 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 was 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 contributing characters were recorded from 5 randomly selected plants in each plot.

Characters recorded

Twenty five genotypes of potato were evaluated for different characters *viz*., plant emergence per cent, plant height, number of compound leaves $plant^{-1}$, number of leaves $plant^{-1}$, number of shoots $plant^{-1}$, plant canopy per cent, fresh weight of shoots $plant^{-1}$, dry weight of shoots $plant^{-1}$, number of tubers $plant^{-1}$, 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 genotypes, 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 :

$$\text{Genotypic variance } (\sigma^2 g) = \frac{TMS - EMS}{\sigma^2 p - \sigma^2 e}$$

$$\text{Environmental variance } (\sigma^2 e) = EMS = \sigma^2 p - \sigma^2 g$$

Where, TMS = Treatment mean sum of square, EMS = Error mean sum of square and $\sigma^2 g$ = Genotypic Variance, $\sigma^2 p$ = Phenotypic Variance and $\sigma^2 e$ = Environmental Variance.

Genotypic and phenotypic coefficient of variation

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

$$GCV\ \% = \frac{\sigma^2 g}{\bar{X}}$$

$$PCV\ \% = \frac{\sigma^2 p}{\bar{X}}$$

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 Sivasubramanium and Madhavamanon (1973).

Heritability

Heritability in broad sense (h^2_b), defined as the proportion of the genotypic variance to the total variance (phenotypic variance) was estimated by using the formula given by Hansen *et al.* (1956).

$$h^2_{bs}\% = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

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

Genetic advance

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

$$\text{Genetic advance} = K \cdot \sigma p \cdot h^2$$

Where, K = Constant value of 2.06 at 5% selection intensity, $ó_p$ = Phenotypic standard deviation of the character and h^2 = Heritability of the character.

Genetic advance as percent of mean

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

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

Where, GA = Genetic advance and 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. High magnitude of phenotypic GCV and PCV (*i.e.* >20 per cent) were observed for number of compound leaves plant^{-1} (27.94 per cent and 30.96 per cent, respectively), followed by dry weight of tubers plant^{-1} (26.26 and 28.91per cent, respectively), marketable tuber yield plot^{-1} (24.74 and 28.168 per cent, respectively), total tuber yield plot^{-1} (24.34 and 27.78 per cent, respectively), fresh weight of shoots plant^{-1} (23.76 and 28.84 per cent, respectively) and fresh weight of tubers plant^{-1} (22.55 and 26.22 per cent respectively. The low magnitude GCV (<10 per cent) was also observed for the character harvest index percentage (8.8 and 11.33 per cent, respectively) number of tubers plant^{-1} (8.18 and 15.5 per cent, respectively), plant emergence per cent (5.13 and 6.61 per cent, respectively) and plant canopy cover per cent (4.14 and 8.19 per cent, respectively) in present study. The above findings indicate that the characters with high magnitude of GCV and can be utilized for improvement as the population possesses considerable variability for these characters.

These findings are in accordance with the findings by Singh *et al* (2015) and Ahmad *et al.* (2005) for number of compound leaves plant^{-1}; Dayal *et al.* (1972) and Chaudhary *et al.* (1984) for total tuber yield; Sharma (1999) for dry weight of shoots plant^{-1}; Basavaraj *et al.* (2005) for fresh weight of tubers plant^{-1}; Kumar *et al.* (2005) for plant height. The moderate GCV and PCV were reported by Luthra *et al.* (2005) and Shashikamal (2006) for fresh weight of shoots plant^{-1} and plant

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

S. No.	Parameters	Mean	Coefficient of Variation (%) Genotypic	Phenotypic
1	Plant Emergence %	88.98	5.13	6.61
2	Plant height (cm)	43.35	13.19	17.94
3	No. of shoots plant^{-1}	5.01	7.58	15.16
4	No. of Leaves plant^{-1}	309.75	7.06	14.78
5	No. of compound leaves plant^{-1}	48.34	27.94	30.96
6	Plant canopy cover %	70.85	4.14	8.19
7	Fresh weight of shoots (gm plant^{-1})	102.55	23.76	28.84
8	Dry weight of shoots (gm plant^{-1})	18.39	15.40	21.57
9	Number of tubers plant^{-1}	4.62	8.18	15.50
10	Fresh weight of tubers (gm plant^{-1})	230.36	22.55	26.22
11	Dry weight of tubers (gm plant^{-1})	55.54	26.26	28.91
12	Harvest Index %	68.08	8.80	11.33
13	Marketable tuber yield (Kg plot^{-1})	12.67	24.74	28.168
14	Total tuber yield (Kg plot^{-1})	13.16	24.34	27.78

height. Singh (2008) reported maximum GCV and PCV for marketable tuber yield plot^{-1}.

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: Estimate of heritability was recorded highest for the character dry weight of tubers plant^{-1} (82.5 per cent) followed by number of compound leaves plant^{-1} (81.4 per cent), marketable tuber yield plot^{-1} (77.1 per cent), total tuber yield plot^{-1} (76.8 per cent) and fresh weight of tubers plant^{-1}(73.9 per cent). However, low heritability was observed in number of shoots plant^{-1} (24.1 per cent), number of leaves plant^{-1} (22.8 per cent), plant canopy cover percentage (25.5 per cent) and number of tubers plant^{-1} (27.8 per cent). Presence of high heritability 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. The present findings on heritability are in accordance with findings reported by the various workers *viz.* Singh (2008) 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} and total tuber yield plot^{-1}. Chandrakar (2007), Basavaraj *et al*. (2005), Biswas *et al.* (2005), Bhagowati *et al.* (2002), Luthra (2001), Desai and Jaimini (1997b), Chaudhary *et al.* (1984) and Gaur *et al.* (1978b) reported high heritability for various component traits in potato.

Highest estimates of genetic advance as percentage of mean were obtained for characters namely number of compound leaves plant^{-1} (51.94 per cent) , dry weight of tubers plant^{-1} (49.154 per cent), marketable tuber yield plot^{-1} (44.738 per cent), total tuber yield plot^{-1} (43.921 per cent) and fresh weight of shoots plant^{-1} (40.338 per cent). The high value of genetic advance for these traits showed that these characters are governed by additive genes and selection will be rewarding for the further improvement of such traits. The moderate genetic advance was observed in character namely fresh weight of tubers gm plant^{-1} (39.94 per cent). The presence of moderate genetic advance suggests that both the additive and non-additive variance is operating in these traits. However, the low genetic advance as per cent of mean was observed for the characters such as dry weight of shoots plant^{-1} (22.65 per cent), Plant height (19.99 per cent), harvest index percentage (14.07 per cent), number of tubers plant^{-1} (8.90 per cent), plant emergence percentage (8.22 per cent), number of shoots plant^{-1} (7.81 per cent), number of leaves plant^{-1} (6.957 per cent) and plant canopy cover percentage

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	Plant Emergence %	60.3	7.31	8.215
2	Plant height (cm)	54.0	8.66	19.986
3	No. of shoots plant^{-1}	24.1	0.39	7.811
4	No. of Leaves plant^{-1}	22.8	21.55	6.957
5	No. of compound leaves plant^{-1}	81.4	25.11	51.946
6	Plant canopy cover %	25.5	3.06	4.311
7	Fresh weight of shoots (gm plant^{-1})	67.9	41.37	40.338
8	Dry weight of shoots (gm plant^{-1})	50.9	4.17	22.652
9	Number of tubers plant^{-1}	27.8	0.41	8.901
10	Fresh weight of tubers (gm plant^{-1})	73.9	92.03	39.949
11	Dry weight of tubers (gm plant^{-1})	82.5	27.30	49.154
12	Harvest Index %	60.3	9.58	14.072
13	Marketable tuber yield (Kg plot^{-1})	77.1	5.67	44.738
14	Total tuber yield (Kg plot^{-1})	76.8	5.78	43.921

(4.31per cent). This indicates the presence of non-additive gene effects.

The low genetic advances for characters in spite of their more than 50% heritability, is due to low variability. This shows the importance of genetic variability in improvement through selection. Panse (1957) suggested that effective selection may be done for the characters having high heritability accompanied by high genetic advance which is due to the additive gene effect. He also reported that low heritability accompanied with genetic advance is due to non-additive gene effects for the particular character and would offer less scope for selection because of the influence of environment. Desai and Jaimini (1997) also reported that tuber yield, number of stem, number of leaves, maturity, shoot fresh weight, number of tubers and average tuber weight had high genotypic coefficients of variation, high heritability and high genetic advance irrespective of environments. In agreement to the above results, Pradhan *et al.* (2011) recorded the high heritability and genetic advance for number of leaves; Bhagowati *et al.* (2002) recorded higher and moderate heritability estimates for the characters like leaf number and fresh weight of

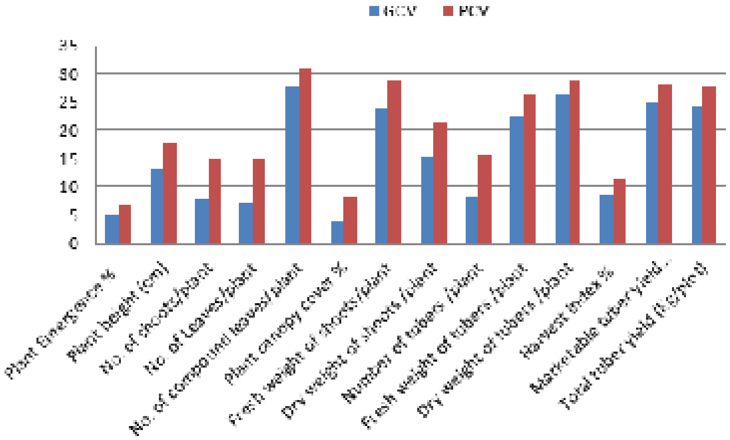

Fig.1. Graphical presentation of Genotypic Coefficient of Variation (GCV) and Phenotypic Coefficient of Variation (PCV) for tuber yield and its components

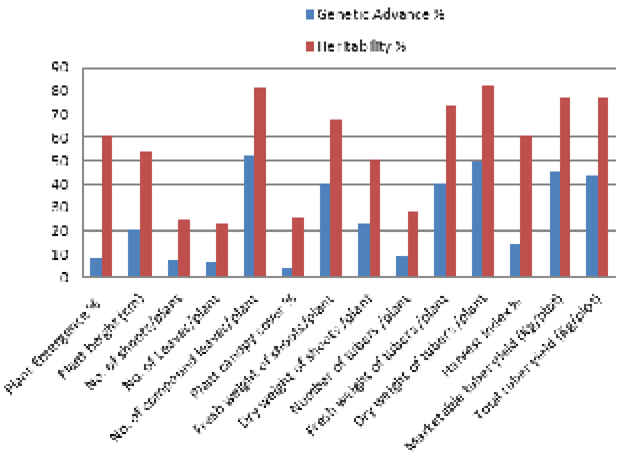

Fig. 2. Graphical presentation of Genetic Advance (%) and Heritability % of tuber yield and its components

tubers plant^{-1}. Barik (2007) reported similar findings for dry weight of tubers plant^{-1} and total tuber yield.

CONCLUSION

The high estimates of heritability recorded for the characters namely, dry weight of tubers plant^{-1}, followed by number of compound leaves plant^{-1}, marketable tuber yield plot^{-1}, total tuber yield plot^{-1} and fresh weight of tubers 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. In the present investigation, high heritability coupled with high genetic advance was recorded for the traits *viz.* dry weight of tubers plant^{-1}, marketable tuber yield plot^{-1} and total tuber yield plot^{-1}. Thus, it can be concluded that these characters may respond effectively to phenotypic selection since it will result in accumulation of more desirable genotypes leading to improvement of these characters.

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