Environment & Ecology 35 (2B) : 1093—1097, April—June 2017
Website: environmentandecology.com ISSN 0970-0420

Genetic Variability, Heritability and Genetic Advance for Yield and Its Attributes in Potato (*Solanum tuberosum* L.)

R. A. Patel, R. T. Bhavani, J. R. Patel, Dixita K. Patel

Received 30 June 2016; Accepted 4 August 2016; Published online 18 August 2016

Abstract A field study was carried out to study the genetic variability, heritability and genetic advance for eleven traits in 42 potato genotypes. Analysis of variance revealed highly significant difference among the genotypes for all the characters studied which indicates the presence of sufficient variability in the experimental material. The phenotypic and genotypic variances were observed high for tubers affected with common scab, plant height, total tuber yield and marketable tuber yield, whereas the rest of characters showed moderate to low magnitude of phenotypic and genotypic variances. The estimates of genotypic and phenotypic co-efficient of variation were high for tubers affected with common scab, reducing sugar, number of tuber per plant, total tuber yield and marketable tuber yield. Broad sense heritability was high for reducing sugar, number of stems per plant, number of tuber per plant, plant height, tubers affected with common scab, chip color, tuber dry matter, marketable tuber yield and total tuber yield. High genetic advance expressed as a percentage of mean was exhibited by tubers affected with common scab, marketable tuber yield, total tuber yield and reducing sugar. The magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as percentage of mean were recorded high for characters like number of stem per plant, number of tuber plant, total tuber yield, marketable tuber yield, reducing sugar and tuber affected with common scab. This indicated that additive gene action is involved in expression of these characters. Therefore, more emphasis should be laid on these component characters for further improvement in tuber yield of potato.

Keywords Genetic variability, Heritability, Genetic advance, Tuber yield, Potato.

R. A. Patel[1], R. T. Bhavani[2]
[1, 2] Department of Genetics and Plant Breeding,
CP College of Agriculture,
Sardarkrushinagar Dantiwada Agricultural University,
Sardarkrushinagar 385506 (Gujarat), India

J. R. Patel*
Castor-Mustard Research Station,
Sardarkrushinagar Dantiwada Agricultural University,
Sardarkrushinagar 385506 (Gujarat), India

D. K. Patel
Department of Genetics and Plant Breeding,
BA College of Agriculture, Anand Agricultural University,
Anand 388110 (Gujarat), India
e-mail : pateljignesh212@gmail.com
*Correspondence

Introduction

Potato (*Solanum tuberosum* L.), a native of South America is one of the major vegetable crops of India

Table 1. Analysis of variance (ANOVA) showing mean squares of eleven characters in potato. *, ** Significant at 5% and 1% levels, respectively.

Sl. No.	Source	Replication	Genotypes	Error
	df	1	41	41
1	Plant height (cm)	1.29	91.11**	15.99
2	Number of stem per plant	0.29	0.81**	0.14
3	Number of tuber per plant	0.30	2.44**	0.23
4	Average weight of tuber per plant (g)	4.85	34.86**	11.30
5	Total tuber yield (t/ha)	0.001	94.17**	5.50
6	Marketable yield (t/ha)	0.37	87.86**	4.96
7	Total soluble solid	0.07	0.04*	0.02
8	Dry matter	0.02	3.94**	0.41
9	Reducing sugar	0.03	20.27**	0.29
10	Chip color	0.00	0.63**	0.03
11	Tubers affected with common scab (%)	5.17	192.22**	3.94

as well as many countries of the world. Indian vegetable basket is incomplete without potato. Potato is a nutritionally superior vegetable due to its edible energy and edible protein. Potato belongs to family *Solanaceae*, genus *Solanum* and an autotetraploid having somatic chromosome number 2n = 48 with the basic chromosome number x = 12 [1]. It consist nine tuber bearing species from which *Solanum tuberosum* L. and *Solanum indigenous* L. have been exploited worldwide for commercial cultivation. It is self-pollinated crop and cross-pollination extent to 2.54%.

The major potato growing states in the India are Uttar Pradesh, West Bengal, Bihar, Assam, Madhya Pradesh, Punjab, Gujarat and Himachal Pradesh. In Gujarat, major potato growing districts are Banaskantha, Mahesana, Kheda, Ahmedabad, Sabarkantha, Baroda, Gandhinagar, Kutch and Jamnagar. Germplasm, which is a prerequisite for any breeding program, serves as a valuable source material as it provides scope for building of genetic variability. Understanding of the nature and magnitude of genetic variability present in the breeding material is important before initiating breeding program. Improvement in yield and its components depend on the nature and magnitude of genetic variability present in the population. It becomes therefore difficult for plant breeder to evaluate and select for complex polygenic characters like yield directly. Hence, to judge whether the observed variability is heritable or not, the primary parameters like genotypic and phenotypic variance, heritability and genetic advance are useful in understanding the nature of inheritance of traits. Considering this the present instigation was undertaken with an objective to study genetic variability, heritability and genetic advance for yield and its attributes in potato.

Materials and Methods

The experiment was conducted with 42 genotypes during *rabi* season of the year 2011–2012 at Potato Research Station, Sardarkrushinagar Dantiwada Agricultural University, Deesa. The material was grown in a randomized complete block design with two replications. Each genotype was represented by three rows plot of 2.0 m × 1.5 m size. The inter and intra row distances were 50 cm and 20 cm respectively which accommodated thirty plants per plot. All the recommended package of practices was followed for successful raising the crop. From each replication five competitive plants selected randomly for recording the observation on 11 characters viz. plant height (cm), number of stems per plant, number of tubers per plant, average weight of tuber (g), tuber dry matter (%), total tuber yield (t/ha), marketable tuber yield (t/ha), chip color, reducing sugar, total soluble solid (TSS) and tubers affected with common scab (per plot). The mean over replication of each character was subjected to statistical analysis. The estimate of genotypic and phenotypic coefficient of variation was calculated according to Burton [2], heritability in broad sense and expected genetic advance as per the procedure of Allard [3].

Results and Discussion

The analysis of variance (Table 1) revealed highly significant differences among the accessions for all the traits. The differences between accessions were significant for all the characters indicating presence of wide genetic variation for different characters in the genetic material studied (Table 1). Significant variation in one or more characters studied in the present investigation have also been reported by several

Table 2. Range of variation, Mean ±SE, CD and components of variance of different characters in potato.

Sl. No.	Characters	Range	Mean ± SE	CD	Variance components		
					Phenotypic	Genotypic	Environmental
1	Plant height (cm)	38.46 – 63.82	50.33 ± 2.83	8.08	53.55	37.56	15.99
2	Number of stem per plant	2.76 – 6.14	3.73 ± 0.27	0.76	0.48	0.33	0.14
3	Number of tuber per plant	2.91 – 8.76	4.77 ± 0.34	0.97	1.33	1.10	0.23
4	Average weight of tuber per plant (g)	42.85 – 57.10	50.73 ± 2.38	6.79	23.08	11.78	11.30
5	Total tuber yield (t/ha)	10.80 – 44.72	26.07 ± 1.66	4.74	49.83	44.34	5.50
6	Marketable yield (t/ha)	7.71 – 36.71	22.73 ± 1.58	4.50	46.41	41.45	4.97
7	Total soluble solid	3.46 – 4.08	3.76 ± 0.10	0.30	0.03	0.01	0.02
8	Dry matter	14.82 – 20.90	17.64 ± 0.45	1.29	2.17	1.76	0.41
9	Reducing sugar	7.75 – 20.16	14.52 ± 0.38	1.09	10.28	9.99	0.29
10	Chip color	2.44 – 4.91	3.48 ± 0.12	0.34	0.33	0.30	0.03
11	Tubers affected with common scab (%)	7.34 – 54.10	27.17 ± 1.40	4.01	98.08	94.14	3.94

workers [4—7] for different characters viz. total tuber yield, number of stems per plant, plant height, dry matter, average weight of tubers, number of tubers per plant, total soluble solid, reducing sugar and chip color.

The phenotypic, genotypic and environmental components of variances were calculated for all the eleven characters under studied (Table 2). The results revealed that magnitude of phenotypic component of variance was higher than genotypic component of variance for all the characters. The genotypic component of variance was found to be higher than the environmental component of variance for all the characters. The higher value of δ^2g and δ^2p were found for tubers affected with common scab per plot i.e. (94.14 and 98.08) respectively. The lowest value of δ^2g and δ^2p were recorded for total soluble solid i.e. (0.01 and 0.03), which were followed by chip color i.e. (0.03 and 0.33) and number of stems per plant i.e. (0.33 and 0.48) respectively. So the result suggested that these three characters were less affected by environment as compared to other characters.

The genotypic variance followed the trend of phenotypic variance was greater than environmental variance for all the eleven characters under studied (Table 2). This indicated that phenotypic variability may be considered a reliable measure of genetic variability. High values of genotypic and phenotypic variance were observed for average weight of tuber per plant, plant height, tuber affected with common scab, total tuber yield and marketable yield in the present investigation. The similar results were reported in potato for total buber yield by Gopal [8], for number of stem per plant and plant height by Ahmad et al. [5].

Genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV)

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for all the traits are presented (Table 3). Higher expression of genotypic coefficient of variation was observed for tubers affected with common scab (35.71), marketable tuber yield (28.33), total tuber yield (25.54) and number of tuber per plant (22.01). The moderate genotypic coefficient of variation was observed for the character viz. reducing sugar (21.78), chip color (15.70), number of stem per plant (15.49), plant height (12.18). Whereas, dry matter (7.53), average weight of tuber per plant (6.77) and total soluble solid (2.47) showed lower magnitude of genotypic coefficient of variation.

The estimates of phenotypic coefficient of variation were ranged from 4.62 (total soluble solid) to 36.45 (tubers affected with common scab). Character such as tubers affected with common scab (36.45), marketable tuber yield (29.98), total tuber yield (27.07) and

Table 3. The estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (%), expected genetic advance and expected genetic advance as percentage of mean for various characters in potato.

Sl. No.	Source	GCV	PCV	Heritability (%)	GA	GA (%)
1	Plant height (cm)	12.18	14.54	70.13	10.57	21.01
2	Number of stem per plant	15.49	18.50	70.16	1.00	26.74
3	Number of tuber per plant	22.01	24.19	82.77	1.69	41.24
4	Average weight of tuber per plant (g)	6.77	9.47	51.04	5.05	9.96
5	Total tuber yield (t/ha)	25.54	27.07	88.97	12.94	49.62
6	Marketable yield (t/ha)	28.33	29.98	89.30	12.53	55.15
7	Total soluble solid	2.47	4.62	28.54	0.10	2.72
8	Dry matter	7.53	8.36	81.17	2.47	13.98
9	Reducing sugar	21.78	22.09	97.19	6.42	44.22
10	Chip color	15.70	16.43	91.34	1.08	30.91
11	Tuber affected with common scab (%)	35.71	36.45	95.98	19.58	72.06

number of tuber per plant (24.19) were exhibited high phenotypic coefficient of variation. Whereas phenotypic coefficient of variation was moderate for reducing sugar (22.09), number of stem per plant (18.50) and chip color (16.43) while, remaining characters showed lower phenotypic coefficient of variation.

In present investigation (Table 3) high GCV (%) as well as PCV (%) was observed for tuber affected with common scab, reducing sugar, number of stems per plant, marketable tuber yield, chip color, number of tubers per plant and total tuber yield. This suggested that the greater variability for these characters among the varieties was due to genetic causes which are less affected by environment and hence could be improved through selection method, while the rest of the characters viz. plant height, average weight of tubers, tuber dry matter and total soluble solid showed low GCV and PCV percentage which indicated the limitation of selection for these characters.

The similar results have also been reported in potato for total tuber yield by Gopal [8], for tuber weight by Bhagowati et al. [9], for plant height and tuber weight per plant by Basavaraja et al. [4], high PCV (%) for tuber yield and average tuber weight by Luthra et al. [10] and high GCV (%) for number of tubers per plant and average weight of a tuber by Sattar et al. [6].

Heritability and genetic advance

The estimates of heritability as percentage in broad sense for all the characters under study are presented (Table 3). A high heritability value was recorded for reducing sugar (97.19), tubers affected with common scab (95.98), chip color (91.34) and marketable yield (89.30). However, total tuber yield (88.97), number of tuber per plant (82.77), dry matter (81.17) and number of stem per plant (70.16) exhibited moderate heritability while, remaining characters showed lower heritability.

In the present study, high broad sense heritability was recorded for reducing sugar, tuber affected with common scab, chip color, marketable tuber yield, total tuber yield, number of tuber per plant and dry matter. Similar findings have been also observed for tuber number and average tuber weight by Bhagawati et al. [9], for tuber yield, tuber number and average tuber weight by Luthra et al. [10], for plant height,chip color, reducing sugar, number of tuber per plant, number of stem per plant and tuber dry matter, total tuber yield, average weight of tuber by Kumar et al. [11], for number of tubers per plant and average weight of a tuber by Sattar et al. [6] and for total soluble solid and dry matter by Sashi [7]. However, research of Sashi [7] is dissimilar to the present research, since they have recorded low to moderate heritability values for total tuber yield, plant height and number of tuber per plant.

The high estimates of heritability values indicate that a large proportion of phenotypic variability for concerned character was heritable. Hence simple selection would be effective for improvement of these traits. The heritability as such has not much significance as it include both additive and epistatic gene effects. It is therefore, necessary to evaluate the heritability estimates along with genetic advance because

genetic advance is the product of the heritability, phenotypic standard deviation and selection differential [12].

The expected genetic advances with respect to eleven characters at 5.00% selection intensity were calculated. Since, these values were not comparable, they were espressed as expected genetic advance in percentage and are presented (Table 3). Genetic advance expressed as percent of mean of different characters ranged from 2.72 to 72.06. The highest value of GA (percent mean) observed for tubers affected with common scab (72.06), also of higher magnitude for marketable tuber yield (55.15), total tuber yield (49.62), reducing sugar (44.22). The lowest value of GA (percent mean) was observed for total soluble solid (2.72) followed by average weight of tuber per plant (9.96) and dry matter (13.98). The remaining characters recorded moderate values of GA (percent mean).

Thus in the present study, genetic advance was high for plant height, total tuber yield, reducing sugar, number of stem per plant, number of tuber per plant, tuber affected with common scab. The similar results have been obtained for tuber number and average tuber weight by Bhagawati et al. [9], for plant height, number of tubers per plant and average tuber weight by Basavaraja et al. [4], for tuber yield, tuber number and average tuber weight by Luthra et al. [10], for number of stem and number of tuber per plant by Ahmad et al. [5] and for number of tubers per plant and average weight of a tuber by Sattar et al. [6].

From the above discussion it is clear that the characters like number of stem per plant, number of tuber per plant, total tuber yield, marketable tuber yield, reducing sugar and tuber affected by common scab exhibited higher magnitude of genetic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability and genetic advance as a percent of mean indicating their importance as selection index for further amelioration of tuber yield in potato.

References

1. Prakken R, Swaminathan MS (1952) Cytological behavior of some interespecific hybrids. Genetica 26 : 76—101.
2. Burton GM (1952) Quantitative inheritance in grasses. Proc 6th Int Grass Cong 1 : 277—283.
3. Allard RW (1960) Principle of plant breeding, John Willey and Sons, New York.
4. Basavaraja N, Naik KR, Naik KS, Gayatri GN (2005) Genetic variability studies in potato (*Solanum tuberosum* L.). Potato J 32 : 233—256.
5. Ahmad I, Hossain M, Islam GMR, Billah SKM, Kabir Y (2005) Genetic variability and correlation studies in potato (*Solanum tuberosum* L.). Int J Sust Agric Technol 1 : 30—34.
6. Sattar MA, Sultana N, Hossain MM, Rashid MH, Islam MA (2007) Genetic variability, correlation and path analysis in potato (*Solanum tuberosum* L.). Bangladesh J Pl Breed Genet 20 : 33—38.
7. Sashi Kamal (2011) Variability and association for morphological and biochemical traits in potato. Ind J Genet 71 : 74—77.
8. Gopal J (2001) *In vitro* and *in vivo* genetics parameters and character associations in potato. Euphytica 118 : 145—151.
9. Bhagowati PR, Saikia M, Sut D (2003) Variability, heritability, genetic advance and characters association in true potato seed (TPS) population. J Agric Sci Soc 15 : 119—122.
10. Luthra SK, Gopal J, Pandey SK, Singh BP (2005) Genetic parameters and character association in *Tuberosum* potatoes. Potato J 32 : 234.
11. Kumar D, Ezekiel R, Khurana SMP (2003) Effect of location, season and cultivar on the processing quality of potatoes. J Ind Potato Assoc 30 : 247—251.
12. Johnson HW, Robinson HF, Comstock RE (1955) Estimates of genetic and environmental variability in soyabean. Agron J 47 : 314—318.