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Response to Selection and Decline in Variability, Heritabilty and Genetic Advance from F2 to F3 Generation of Tomato (Solanum Lycopercicum)

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Abstract Success of breeding programme depends upon response to selection, heritability and genetic advance so, assessment of these parameters is important. In our research the data on F2 and F3 generations of *Solanum Lycopersicum* were collected in 2015 and 2016, respectively and the values of mean, range, selection differential, heritability, genetic advance and response to selection were calculated for both the generations. The phenotypic variance, genotypic variance, heritability and genetic advance % was found to be higher in F2 generation than in F3 for all the parameters. Highest value of heritability% was observed for fruit diameter while lowest value was estimated for flowers/cluster in F2 generation. In F3 generation highest value of heritability was found for fruit weight and the lowest value was calculated for yield/plant. Highest and lowest genetic advance % was calculated for number of fruits/plant and yield/plant in F2 and for fruit weight and yield/plant in F3, respectively. The maximum and minimum range in F2 was observed to be wider than in F3.Selection differential and response to selection were found to be positive for all the parameters. The study reveals that judicious selection leads to improvement in next generation.

Keywords Tomato, F2, F3, Range, Mean, Selection response, Heritability, Variability, Genetic advance

1. Introduction

Tomato (*Solanum Lycopersicum*) is a self pollinated diploid plant species with chromosomes number 2n=24. It has diversity in various morphological features which are helpful in genetic study at any population level. Like other self pollinated crops, breeders apply selection, testing and screening in early generation according to desirable goals. Early generation testing helps them increase the breeding efficiency by choosing superior genotypes and eliminating inferior lines from heterozygous population [1]. Early generation selection is successful for fissure resistance in rice [2]. Selection at F2 and F3 stages is useful and delayed selection does not bear any fruitful result. Ignoring the selection in early generations may lead to drifting of superior genotypes [3].

Segregation is maximum for selection in F2 generation [4]. Heterozygosity, which is highest at F2 stage decreases in F3 generation, as with every advance in generation, it decreases by 50% in a population [5].Therefore, in F2 generation selection is applied on individual plant while at F3 stage it is applied within the F3 line.

Selection increases the population genotypic mean for a particular trait [6]. The increase in means results in positive value of selection differential and selection response in next generation. Selection is effective from F2 to F3 generation of tomato for late blight resistance [7].

Some time a breeder may face the problem of low performance of F3 or F2 selected lines in next generation. Low efficiency of selection in F2 and F3 generation may be due to environmental factors which mask the expression of genes; consequently high and low yielding lines cannot be discriminated [8]. Therefore, It is essential in breeding programme to study heritability and genetic advance as well as selection response and selection differential. The concept of heritability has enabled breeders to find the efficacy of selection as well as determines the environmental effects and hence selection efficiency can be measured [9]. The estimate of heritability and genetic advance in early generation selection are useful in finding response to selection for yield and yield components. Selection differential measures the intensity of artificial selection. Response to selection gives us information about the change in mean from previous

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generation to next generation; hence it is the product of selection differential and narrow-sense heritability [10].

The purpose of our study is to find the efficiency of lines selected from F2 generation at F3 stage by finding the heritability, genetic advance and selection response. The study will also make comparison between F2 and F3 population regarding variation, heritability and selection differential, mean and range.

2. Materials and Methods

Field practices and data collection: Two varieties of tomato, Nagina and Bushbeef steak having distinct characteristics were sown as nursery and after 45 days of sowing mature plantlets were transplanted in the field at Hazara agricultural research station Abbottabad during June 2013. NPK fertilizer was applied to plants at flowering stage. Weeds were eradicated by manual practice. The flowering started in July 2013 and Nagina was used as line and Bush beefsteak was used as tester. The flowers of Nagina variety were emasculated and pollens from bush beefsteak were used for pollination. After pollination, tagging and bagging of the cross pollinated flower was done in a proper way. After the ripening of fruit, seeds were collected as F1. The collected seeds were grown as nursery and transplanted in the field in March 2014. The fertilizer and other practices were applied as mentioned above. F2 seeds were collected from F1 plants on maturity. The seeds along with parental varieties were sown as nursery in January 2015 and 45 days old nursery was transplanted in the field. The data on F2 population and parental varieties were collected on the parameters: Flowers/cluster, fruits/cluster, fruit diameter, fruit length, fruit weight, No of fruits/plant and yield/plant. The plants according to desirable traits were selected from F2 generation and seeds were collected. F3 seeds along with parental varieties were sown in nursery in January 2016. 45 days old plants were transplanted in the field and data were collected on the parameters mentioned above.

Statistical data analysis

Data collected from F2 and F3 lines were subjected to statistical analysis whose detail is given as following.

Mean, range, Variance of environment (Ve) and Variance of phenotype (Vp) were found by using the statistix 8.1 software.

$$Ve=Vp1+Vp2/2$$

Where P1 is first parent in crossing and P2 is second parent in crossing

Vg (Variance of geneotype) was found by the following formula

$$\text{As } Vp=Vg+Ve \text{ so } Vg=Vp-Ve$$

Va (additive variance) in F3 generation was found by applying the formula suggested by [11] as following.

The Vg between means of F3 lines =Va + 1/4Vd

Where Va= Variance due to additive gene action and Vd=Variance due to dominant gene action

The value of Vd is very small, if we ignore it it will not make any difference

Therefore

Vg between means of F3 line =Va

Response to selection (RS) was found by using the following method applied by [12]

$$RS=ih\,\acute{O}P$$

Where i: selection intensity with value of 1.76 at 10%, h: heritability and ỚP: phenotypic coefficient of variation.

Heritability% in F2 and Genetic advance % in F2 and F3 were calculated according to following formulas used by [13] in their study.

$$Hb = \{VF2 – [1/3 (VP1 + VP2 + VF1)]\}/VF2$$

Where Ve=Vp1 +Vp2+Vf1/3 and Vp=VF2

Vg=Vp-Ve

So, Hb=Vg/Vp Hb%=Hb x 100

GA%=GA/x × 100

Where Hb%: broad sense heritabilty %, Vp: Phenotypic variance, Vg: genotypic variance, Ve: variance of error, GA:genetic advance and GA%: genetic advance % in percentage of means.

Heritabilty in F3 was calculated according to following method:

$$H\%=Va/Vp \times 100$$

Va in the F3 population has already been discussed above.

Selection differential was found by subtracting means of F2 population from means of F3 population SD=F3-F2.

3. Results and Discussion

Mean values of all the parameters like flowers/cluster, Fruits/cluster, Fruit diameter, fruit length, fruit weight, number of fruits/plant and yield/plant are higher in F3 population than in F2 (Table 1). The selection practice generation after generation leads to increase in mean of the population [14]. While proceeding from F2 to F3 generation, dominant gene action decreases and additive gene action increases [15] so, the increase in means values in F3 generation may be attributed to additive gene action.

Positive value of selection differential was calculated for all the parameters. Yield/plant showed the maximum value (1004.35) of selection differential (Table 1). Selection based on genotypic values may lead to increase in mean of selected population in next generation resulting in positive value of selection differential.

The minimum and maximum range in F2 is wider than that in F3. Vg in F2 was found to be greater than Va in F3 lines for all the parameters. Value of Vp was found to be higher in F2 than Vp value in F3 (Table.1). The wider minimum and maximum range in F2 generation is correlated to Vg, higher the Vg, wider the range. Since F2 generation is more heterozygous than F3 generation, therefore, number of allelic combinations are higher which result in higher values of

Vg,Vp and increase in range. Besides, dominant and additive gene actions are involved in F2. In F3 there is little role of dominant gene action. Artificial selection on the basis of our desired traits is also one of the important factors responsible for reducing the Vg,Vp and range in F3 generation. Through selection, frequency of the genes is fixed to a certain limit which causes the aforementioned effects. Decrease in genetic variability in pigeon-pea from F2 to F3 generation for some traits was also noticed [16].

By comparing the heritability between F2 and F3 it was found that the value of heritability % for all the parameters was greater in F2 than in F3. In F2 generation highest value of H% was found for fruit diameter (84.08%) while lowest value of H% was noted for the trait fruits/cluster (27.58%). In F3 generation highest heritability (30.64%) was noted for fruit weight while lowest heritability (0.80%) was found for yield/plant (Table. 2). Selection from one generation to next generation changes the gene frequency. Since heritability depends on gene frequency, so any change in it causes change in heritably in next generation. Decrease in heritability in next generation is due to decrease in segregation and increase in homogeneity [17]. Decline in hereditary value from F3 to F5 generation were also recorded [18], which confirms our findings.

Genetic advance in percentage of mean (GA%) was also found to be higher in F2 than in F3 for all the parameters. In F2 generation highest GA% was found for number of fruits/plant (117.43) while lowest GA% was calculated for yield/plant (15.22). In F3 generation highest GA% was calculated for fruit weight (18.28) while lowest GA% was calculated for yield/plant (0.79) (Table. 2). Decline in value of Vp from F2 to F3 generation leads to decrease in the value of GA%, since it depends upon Vp [19].

Positive response to selection from F2 generation to F3 generation was noticed for all the parameters. The highest value (20.69) was calculated for fruit weight, followed by yield/plant (8.05). The lowest value (0.18) for response to selection was noted for flowers/cluster. Selection results in increase in the frequency of certain alleles and elimination of others leading to changes in genotypic and phenotypic values of the offsprings which exhibit better performance than their parents [20]. Our results matched to the findings of [21] who also found positive response to selection for several yield components and morphological traits in his study on rice. Response to selection for yield/plant is higher than some other parameters but heritability percentage was found to be lowest (0.80%) for the said parameter. It is assumed for higher response to selection value with low heritability that the low heritability may be due to environmental error and not due to lack of genetic variation [22].

Table 1. Mean, range, selection differential (SD), genotypic variance (Vg) and additive variance (Va) for flowers/clusters (FPC), fruits/cluster (FrPC), fruit diameter (Frdia), fruit length (frlength), fruit weight (Frwt), Number of fruits/plant (NoF) and yield/plant (YPP)

Parameters	Mean		Range		SD	Vg	Va
	F2	F3	F2	F3	F3-F2	F2	F3
FPC	4.18	5.35	1-9	4.5-6.0	1.26	0.48	0.01
FrPC	1.87	3.81	0-6	3.1- 4.3	1.86	0.29	0.01
Frdia	4.60	5.57	2.1-6.5	4.7-6.9	1.02	0.53	0.07
Frlength	4.49	5.45	2.9-6.53	4.9- 6.1	1.03	0.43	0.03
FrWt	63.37	93.03	20-147	67.1- 140.5	30.59	115.7	111.20
NoF	15.07	21.70	0-79	14.4-30.5	6.55	89.47	1.38
YPP	930.85	1890.2	0-3010	1153.7- 2443.7	1004.35	553205	1039

Table 2. Phenotypic variance (Vp), heritabilty percentage (H%), genetic advance in percentage of means (GA%) and response to selection (RS) in F3 for flowers/clusters (FPC), fruits/cluster (FrPC), fruit diameter (Frdia), fruit length (frlength), fruit weight (Frwt), Number of fruits/plant(NoF) and yield/plant (YPP)

Parameters	Vp		H%		GA% in means		RS
	F2	F3	F2	F3	F2	F3	F3
FPC	1.44	0.12	33	14.92	19.72	1.76	0.18
FrPC	1.07	0.11	27.58	11.03	31.44	5.80	0.20
Frdia	0.63	0.30	84.08	26.02	29.89	7.074	0.26
Frlength	0.56	0.13	76.82	28.31	26.55	5.87	0.29
FrWt	328.91	301.39	35.17	30.64	20.73	18.28	20.69
NoF	108.31	19.38	82.60	7.12	117.43	6.16	0.46
YPP	746202	129469	74.13	0.80	15.22	0.79	8.05

4. Conclusions

Selection from previous F generations to next F generation in breeding prorgramme may lead to decrease in variability and heritability. However, on the other hand judicious selection causes increase in mean of the population for certain traits. Since, breeder is concerned with the enhancing of means for the traits; he may get an improved population at the onset of homozygosity at F8 and onward stages.

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