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Residual heterosis, combining ability and gene action studies for quality traits in chilli (*Capsicum annuum* L.)

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Abstract

The estimates of GCA effects showed that the line 'Pusa Sadabahar' observed to be a good general combiner for all three traits *viz*., ascorbic acid, capsaicin content and oleoresin followed by Pusa Jawala and Arka Lohit for oleoresin and capsaicin content. Amongst the testers, 'Surajmukhi' was the most promising as evident from its good GCA for all three traits. On the basis of SCA effects, cross combination 'PAU Selection Long × Surajmukhi' was good specific combiner for all the three quality traits *viz.,* ascorbic acid, oleoresin and capsaicin content. Gene action studies revealed that the estimates of $\acute{o}_{SCA}^2$ were higher than $\acute{o}_{GCA}^2$ (average) for all the traits indicating the predominant role of non- additive gene action governing these traits. The per cent contribution of lines played a significant role in the expression of different characters for total genetic variance in different cross combinations followed by tester and their interactions. The magnitude of dominance variance indicated the involvement of non-additive gene action for all the traits which can be best utilized by deferring selection to the later generations to develop superior open pollinated varieties by advancing segregating material through single seed descent or bulk pedigree method or single fruit descent method with one or two intermatings like recurrent selection or diallel selective mating design.

Keywords: Chilli, heterosis, combining ability, oleoresin, capsaicin

Introduction

Chilli or Hot pepper (*Capsicum annum* var. *annum* L.), a member of family Solanaceae, is one of the valuable cash crop grown in India for its green fruit as vegetable and red fruits as spice. Chilli is an indispensable spice essentially used in every Indian kitchen due to its pungency, taste, appealing colour and flavour. Chillies have two important qualities i.e. pungency and attractive red colour which are attributed to capsaicin and capsanthin, respectively. Pungency of chilli is due to a crystalline acrid volatile alkaloid called capsaicin, present in the placenta of fruit which has diverse prophylactic and therapeutic uses in allopathic and Ayurvedic medicines. Red coloured pigment is used as a natural colour additive in food, drugs and cosmetics. These pigments are also rich in bioflavonoids which are powerful antioxidants and inhibit the progression of chronic diseases such as muscular degeneration, cardiovascular diseases and cancer. Chilli is also a good source of oleoresin which is the total flavour extracted from dried as well as ground chilli and has varied uses in processed food, pharmaceutical formulations and beverage industries.

India has immense potential to export different types of chilli around the world. However, the average yield is low due to various constraints such as non-availability of suitable cultivars/hybrids, genetic drift in cultivars and biotic and abiotic stresses. In any breeding programme initiated with an aim of yield improvement, the cross combinations with high yield *per se* and high heterosis would give desirable results. In chilli, residual heterosis can be exploited for commercial cultivation by selection of promising combinations in the F_2 generation. In the recent past, exploitation of hybrid vigour and selection of parents on the basis of combining ability has been used as an important breeding approach to break the yield plateau. Development of high yielding hybrids (F_1) primarily depends on the extent of heterosis for yield and subsequent elaboration of an economical method of producing the hybrid seed. In the absence of availability of male sterile lines, the cost of hybrid seed production through hand emasculation and pollination becomes expensive. In this context, extent of residual heterosis in F_2 may be utilized to get heterotic effect economically with low cost of seed production. Under

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such situations, it is important to have a clear cut judgement about a particular cross which is likely to produce transgressive recombinants. The recovery of transgressive recombinants will depend upon the heritable hybrid vigour which can be assayed from the presence of heterosis in F_2 or successive generations. The heterotic vigour is mainly controlled by dominant and semi-dominant genes and these genes also regulate inbred vigour and heritability of vigour. Moreover, all the heterotic effects are constantly converted into additive and fixable effects (Fasoulas 1978). Therefore, in self fertilized crops like chilli, the most profitable and the safest way is to identify the potential crosses with high heritable vigour by observing the F_2 generation of the crosses attempted (Fasoulas 1981).

To achieve this goal, the Line × Tester mating design (Kempthorne 1957) is useful in deciding the relative ability of number of female and male inbreds to produce desirable cross combinations. This mating design can also provide information regarding the usefulness of the male and female inbreds as parents for hybridization to generate segregating population which is accepted to give remarkable selections. Keeping this in view, the present study using F_2 generation of 30 crosses derived by involving ten lines and three testers was undertaken for the rapid genetic amelioration of chilli crop to ascertain the extent of residual heterosis in the F_2 generation for fruit yield and related horticultural traits.

Materials and Methods

The present investigation was carried out at the Experimental Farm of the Department of Vegetable Science and Floriculture, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during summer 2013. The Experimental Farm is located at an elevation of about 1290.8 m above mean sea level with 32^{o} 8' North latitude and 76^{o} 3' East longitude, representing mid hill zone of Himachal Pradesh and has a humid-temperate climate with high rainfall (2500 mm per annum). The experimental material comprised of F_2 population of 30 crosses which were developed by crossing 10 lines of chilli *viz*., 'Pusa Sadabahar', 'Arka Lohit', 'LCA 436', 'Pusa Jwala', 'PAU Selection Long', 'Kashmir Long', 'Selection 352', 'LCA 443', 'LCA 206' and 'Chilli Sonal' with three testers *viz*., 'Pant C-1', 'Surajmukhi' and 'Anugraha'. These 30 crosses and their 13 parents were evaluated in Randomized Complete Block Design with three replications. Thirty six plants of each F_2 crosses and six plants of each parent were transplanted in the field on 7th May 2013 with inter and intra-row spacing of 45 cm each in plot size of 2.70×2.70 m.

The observations were recorded in each entry and replication for ascorbic acid (mg/100 g fresh weight), oleoresin (ASTA unit) and capsaicin content (%). For working out the analysis of variance, the data were analysed by using the following model as suggested by Panse and Sukhatme (1984). The estimates of residual heterosis were calculated as the deviation of F_2 mean from the better parent (BP). Line x Tester analysis was done by subjecting mean values of F_2 generation of 30 crosses for each trait over the replications using the model suggested by Kempthorne (1957) and the solved example given by Dabholkar (1992). Per cent contribution of lines, testers and their interactions were computed as per the formulae suggested by Singh and Chaudhary (1977). For computing the additive and dominance components of variances following formulae given by Singh and Chaudhary (1977) and Dabholkar (1992) were used.

Results and Discussion

In the present study, analysis of variance for 30 crosses and their parents revealed significant differences among the parents and crosses for all the traits studied. This indicates that the parents used in the present study were highly divergent which has been also reflected in the varying performance of different cross combinations as evident from the significant differences among the crosses. The significance of mean squares due to crosses for all the traits revealed that the crosses were sufficiently different from each other for majority of the traits and hence, selection is possible to identify the most desirable transgressive segregants.

Residual heterosis

In addition to hybrid vigour, the main interest of breeders would be in isolating recombinants exhibiting transgressive vigour. The cross combinations which are likely to produce transgressive recombinants in the succeeding generations would mainly depend upon residual heterosis in F_2 generation or the heritability of hybrid vigour and combining ability effects (Fasoulas 1981). This warrants yield test of all cross combinations in F_1 and subsequently in F_2 in order to see the consistency of hybrid vigour whether it is retained or broken down. If vigour is maintained, the dominant genes are involved otherwise they are co-dominant. This reflects that exploitation of heterosis should not be considered as the only final goal but it should be considered as a bridge that leads to further improvement through exploitation of inbred vigour by isolating transgressive segregants in the successive generations in a crop like chilli. Pooni (1985, 1986) has demonstrated that it is possible to select inbred lines superior to heterotic F_1 or better parent.

The desirable residual heterosis was exhibited by ten cross combinations over better parent for ascorbic acid (Table 1). The top five cross combinations which exhibited the residual heterosis over better parent were 'Kashmir Long × Anugraha', 'Pusa Sadabahar × Surajmukhi', 'PAU Selection Long × Surajmukhi', 'Pusa Sadabahar × Anugraha' and 'Kashmir Long × Surajmukhi'. Heterosis in F_1 for ascorbic acid has been reported earlier by Gondane and Deshmukh (2004) and Adapawaret al. (2006). For oleoresin content, residual heterosis was revealed for nine cross combinations over better parent. 'Kashmir Long × Pant C-1', 'LCA 443 × Pant C-1', 'Selection 352 × Pant C-1', 'Selection 352 × Surajmukhi' and 'PAU Selection Long × Surajmukhi' were placed amongst the top five**.** Prasath and Ponnuswami (2008) also observed hybrid vigour in F_1 for oleoresin. Only seven crosses showed significant positive residual heterosis for capsaicin over better parent, of which 'LCA 443 × Anugraha', 'ArkaLohit × Anugraha', 'LCA 206 × Pant C-1' were the top ranking three cross combinations for high capsaicin content. Milerue and Nikornpun (2000) and Prasath and Ponnuswami (2008) revealed heterosis in F_1 for this trait.

Estimation of general combining ability (GCA) effects: 'Pusa Sadabahar' was observed to be good general combiner for all these three quality traits (Table 2). In addition, the other lines which showed good GCA effects were 'PAU Selection Long' for ascorbic acid and oleoresin, 'Arka Lohit' and 'Pusa Jwala' for oleoresin and capsaicin content, 'Kashmir Long' for ascorbic acid, 'Selection 352' and 'LCA 443' for oleoresin and 'LCA 206' for capsaicin contents. Good general combiner lines involving F_1's have also been reported by Singh and Hundal (2001), Prasath and Ponnuswami (2008) and Lohithaswaet al. (2001) in different studies in their respective environments for oleoresin and capsaicin content. Amongst the testers, 'Surajmukhi' was observed to be good general combiner for ascorbic acid, oleoresin and capsaicin content having the significant positive GCA effects (Table 4). Anugrahaand 'Pant C-1' revealed desirable and significant positive GCA effects for ascorbic acid and oleoresin, respectively.

Table 1: Estimates of heterosis (%) in F_1 and residual heterosis (%) in F_2 generation for ascorbic acid, oleoresin and capsaicin content over better parent in chilli

S. No	Crosses	Ascorbic acid		Oleoresin		Capsaicin content	
		2011 (F_1)	2013 (F_2)	2011 (F_1)	2013 (F_2)	2011 (F_1)	2013 (F_2)
1.	PusaSadabahar × Pant C-1	-7.34*	-7.96*	-7.33*	-9.80*	-14.75*	13.33*
2.	PusaSadabahar × Surajmukhi	12.24*	17.79*	0.65	-1.49	-21.46*	-24.02*
3.	PusaSadabahar X Anugraha	11.20*	16.98*	2.59	-0.37	-12.30*	8.00*
4.	ArkaLohit × Pant C 1	5.79*	-8.78*	19.70*	1.36	3.98	14.12*
5.	ArkaLohit × Surajmukhi	-19.24*	-19.39*	8.86*	0.13	-13.03*	-13.97*
6.	ArkaLohit × Anugraha	7.02*	-0.09	19.49*	-1.39	**37.91***	26.62*
7.	LCA436 × Pant C-1	**-28.44***	-25.57*	-2.99	-2.90	-27.36*	-30.59*
8.	LCA436 × Surajmukhi	3.39*	2.61	-20.00*	-19.80*	-41.76*	-43.23*
9.	LCA436 × Anugraha	1.51	-2.72	-47.59*	5.16	-23.67*	-31.88*
10.	PusaJwala × Pant C-1	-25.35*	-24.24*	0.83	2.98	-0.76	4.07
11.	PusaJwala × Surajmukhi	-8.55*	-7.30*	-4.75*	-0.04	1.91	0.00
12.	PusaJwala × Anugraha	1.36	7.33*	-1.24	1.20	-9.92*	-8.13*
13.	PAU Selection Long × Pant C-1	-19.95*	-19.73*	1.36	18.42*	-23.88*	-31.28*
14.	PAU Section Long × Surajmukhi	**14.16***	17.46*	3.80	18.64*	-28.35*	-12.23*
15.	PAU Selection Long × Anugraha	3.63*	9.06*	-7.85*	1.78	4.73	-15.38*
16.	Kashmir Long × Pant C-1	-5.15*	-7.51*	**32.88***	**36.46***	23.88*	-4.12
17.	Kashmir Long × Surajmukhi	7.82*	10.64*	1.52	-1.82	-28.35*	-25.33*
18.	Kashmir Long × Anugraha	13.91*	**18.94***	-18.23*	-19.09*	8.84*	-2.94
19.	Selection 352 × Pant C-1	-24.32*	-23.15*	20.11*	19.56*	3.98	2.35
20.	Selection 352 × Surajmukhi	-6.94*	-4.87*	18.23*	18.74*	-17.24*	-15.72*
21.	Selection 352 × Anugraha	-14.98*	-8.73*	8.35*	9.23*	40.82*	16.91*
22.	LCA 443 × Pant C-1	-7.59*	-8.15*	20.65*	27.66*	4.48*	2.35
23.	LCA 443 × Surajmukhi	-3.98*	-0.26	9.11*	9.10*	-22.61*	-20.96*
24.	LCA 443 × Anugraha	-10.14*	-4.54*	-6.58*	-9.78*	21.09*	**29.41***
25.	LCA 206 × Pant C-1	-24.58*	**-28.07***	4.08	-3.65	-22.39*	25.88*
26.	LCA 206 × Surajmukhi	8.85*	9.26*	7.85*	7.30*	-16.48*	-10.04*
27.	LCA 206 × Anugraha	-3.78*	4.24*	-3.29	-1.79	16.85*	2.21
28.	ChilliSonal × Pant C-1	-11.45*	-10.96*	-29.89*	-28.22*	**-50.75***	**-54.71***
29	ChilliSonal × Surajmukhi	-8.55*	-9.18*	-19.49*	-19.31*	-46.74*	-41.92*
30.	ChilliSonal × Anugraha	-0.45	4.10*	**-59.75***	**-58.68***	-31.29*	-27.94*
	Number of significant genotypes	9	10	10	9	7	7

* Significant at P d" 0.05

Table 2: Estimates of general combining ability (GCA) effects of lines and testers for fruit quality traits

Traits/Lines	Ascorbic acid (mg/100g)	Oleoresin (ASTA units)	Capsaicin content (%)
Lines			
Pusa Sadabahar	13.47*	8.35*	0.17*
Arka Lohit	-0.50	4.93*	0.05*
LCA436	-6.01*	-7.30*	-0.20*
Pusa Jwala	-6.40*	11.82*	0.23*
PAU Sel Long	5.42*	4.27*	-0.02*
Kashmir Long	13.08*	-0.86	-0.06*
Sel352	-11.14*	6.10*	0.01
LCA443	-0.81	1.65*	0.01
LCA206	-3.81*	-3.24*	0.04*
Chilli Sonal	-3.30*	-25.74*	-0.23*
SE(gi)±	0.70	0.69	0.009
SE(gi -gj)±	0.99	0.98	0.01
CD (5%)	1.41	1.39	0.01
Testers			
Pant C-1	-2.9*	1.96*	0.01
Surajmukhi	2.14*	1.48*	0.03*
Anugraha	0.80*	-3.44	-0.04*
SE(gi)±	0.38	0.38	0.005
SE(gi-gj)±	0.54	0.53	0.007
CD (5%)	0.77	0.76	0.01

*Significant at P d” 0.05

Significance of GCA effects for majority of the traits in different sets of testers was reported earlier by Pandian and Shanmugavelu (1992), Singh and Hundal (2001), Patel et al. (2004), Srivastava et al.(2005) and Reddy et al. (2008) in F_1.

Estimation of specific combining ability (SCA) effects of crosses: Significant positive SCA effects were recorded in twelve cross combinations for ascorbic acid, ten for oleoresin and seven for capsaicin (Table 3). Among these cross combinations, 'LCA 206 × Surajmukhi' (Poor × Good), 'LCA 443 × Pant C-1'(Average × Poor), 'PAU Selection Long ×Surajmukhi'(Good × Good), 'ChilliSonal× Pant C-1'(Poor × Poor) and 'ArkaLohit × Pant C-1' (Average × Poor) for ascorbic acid, 'Kashmir Long × Pant C-1' (Average × Good), 'LCA 436 × Anugraha'(Poor × Poor), 'ChilliSonal× Surajmukhi'(Poor × Good), 'LCA 443 × Pant C-1'(Good × Good) and 'PusaSadabahar× Anugraha' (Good × Poor) for oleoresin and in crosses 'PusaSadabahar × Anugraha'(Good × Poor), 'PusaSadabahar × Pant C-1'(Good × Poor), 'LCA 206

Table 3: Estimates of specific combining ability (SCA) effects for quality traits

S. No.	Crosses	Ascorbic acid (mg/100g)	Oleoresin (ASTA units)	Capsaicin content (%)
1	PusaSadabahar × Pant C-1	-2.75*	-6.51*	0.10*
2	PusaSadabahar × Surajmukhi	3.42*	0.37	-0.20*
3	PusaSadabahar X Anugraha	-0.67	6.15*	0.11*
4	ArkaLohit × Pant C 1	10.17*	-1.03	0.01
5	ArkaLohit × Surajmukhi	-16.96*	-1.41	-0.01
6	ArkaLohit × Anugraha	6.78*	2.44*	-0.002
7	LCA436 × Pant C-1	-5.61*	-2.55*	0.01
8	LCA436 × Surajmukhi	6.42*	-9.38*	0.02
9	LCA436 × Anugraha	-0.81	11.93*	-0.03
10	PusaJwala × Pant C-1	-3.53*	-0.74	0.04*
11	PusaJwala × Surajmukhi	-3.95*	-2.56*	-0.02
12	PusaJwala × Anugraha	7.48*	3.30*	-0.01
13	PAU Sel Long × Pant C-1	-9.62*	-1.44	-0.12*
14	PAU Sel Long × Surajmukhi	11.12*	3.22*	0.08*
15	PAU Sel Long × Anugraha	-1.49	-1.78	0.04*
16	Kashmir Long × Pant C-1	-1.80	14.42*	0.02
17	Kashmir Long × Surajmukhi	-3.94*	-4.51*	0.02
18	Kashmir Long × Anugraha	5.74*	-9.91*	-0.04*
19	Sel 352 × Pant C-1	2.60*	-2.59*	-0.01
20	Sel 352 × Surajmukhi	3.43*	1.46	-0.03
21	Sel 352 × Anugraha	-6.02*	1.13	-0.01
22	LCA 443 × Pant C-1	11.29*	6.67*	-0.02
23	LCA 443 × Surajmukhi	-1.89	-0.16	-0.02
24	LCA 443 × Anugraha	-9.39*	-6.51*	0.04
25	LCA 206 × Pant C-1	-10.97*	-7.06*	0.08*
26	LCA 206 × Surajmukhi	11.45*	3.06*	0.03
27	LCA 206 × Anugraha	-0.48	3.46*	-0.12*
28	ChilliSonal × Pant C-1	10.21*	0.83	-0.09*
29	ChilliSonal × Surajmukhi	-9.09*	9.37*	0.07*
30	ChilliSonal × Anugraha	-1.13	-10.20*	0.03
	SE (sij)±	1.22	1.20	0.01
	SE (Sij-Skl) ±	1.72	1.70	0.02
	CD 5 (%)	2.44	2.41	0.03

*Significant at P d” 0.05

× Pant C-1'(Poor × Poor), 'ChilliSonal× Surajmukhi'(Poor × Good)and 'PusaJwala × Pant C-1'(Good × Poor) for capsaicin were placed among the top ranking five specific cross combiners with desirable SCA effects. Overall, it was observed that no single cross could reveal significant SCA effects for all the traits. Different cross combinations with significant and positive SCA effects in F_1 have been reported by Sarithaet al. (2005) for ascorbic acid, Prasath and Ponnuswami (2008) and Singh and Hundal (2001) for capsaicin content and Singh and Hundal (2001) and Sarithaet al. (2005) for oleoresin.

On the basis of specific combining ability effects, it can be concluded that 'PAU Sel Long × Anugraha' had shown desirable SCA effects for all the traits. However, 'Arka Lohit × Anugraha','Pusa Jwala × Anugraha', 'LCA 443 × Pant C1' and LCA 206 × Surajmukhi' exhibited significant and desirable SCA effects for two traits namely, ascorbic acid and oleoresin while 'Pusa Sadabhar×Anugraha' showed the same for oleoresin and capsaicin (Table 5). Cross combinations involving parents with high × high interaction between alleles can be fixed in subsequent generations for effective selection if no repulsion phase is involved (Saidaiah et al. 2010). Involvement of both parents with poor GCA effects *e.g.* 'Chilli Sonal× Pant C-1' for ascorbic acid, 'LCA 436 × Anugraha' for oleoresin and 'LCA 206 × Pant C-1' for capsaicin also produced superior specific combiners which has been attributed to dominance × dominance interaction. The specific interaction effects most likely complementary of 'Poor × Poor' crosses may perform better than 'Good × Good' and 'Good × Poor' combinations because of the prevalence of high magnitude of non-additive component for the superiority of the pertinent cross combinations. Prasad and Singh (1994) and Singh et al. (2012) were also of the view that the parents having high estimates of GCA would not necessarily give high estimates of SCA effects. However, the describable performance of combinations like 'high × low' may be ascribed to the interaction between dominant allele of good combiner and recessive allele of poor combiner reflecting the role of both additive and non-additive gene action. This type of gene action revealed that the high potential of such crosses would be unfixable in succeeding generations and hence suggests the importance of breeding methods like reciprocal recurrent selection and diallel selective mating system in the improvement of quality traits in chilli. Furthermore, many of the cross combinations showed non-significant SCA effects (average effects) but originated from parents having high GCA effects. This is possible only in the absence of any interaction among favourable alleles contributed by the parents. Thus, it is evident that two parents with high GCA effects for a trait may not always result in a combination showing high SCA effects (Singh et al. 2009 and Singh et al. 2012).

Table 4: Estimates of genetic components of variance for different quality traits in chilli

Traits /Genetic Components	Ascorbic acid (mg/100g)	Oleoresin (ASTA units)	Capsaicin content (%)
σ_{GCA}^2 (Lines)	38.13	93.74	0.02
σ_{GCA}^2 (Testers)	-1.97	3.09	0.001
σ_{GCA}^2 (Average)	1.92	5.02	0.001
σ_{SCA}^2	87.28	56.9	0.01
σ_A^2	3.83	10.03	0.002
σ_D^2	87.28	56.9	0.01
Heritability % (narrow sense)	4.14	14.67	21.99
Genetic advance	0.82	2.5	0.04

Gene action: In a breeding programme, once the appropriate parents and potential crosses are identified, the next essential step is to adopt a suitable breeding strategy for the purposeful management of generated variability which largely depends upon the type of gene action in the population for the traits under genetic improvement (Cockerham 1961, Sprauge 1966). Various mating designs have been developed for this purpose and among them Line × Tester method (Kempthrone 1957) not only evaluates parents and crosses for combining ability but also provides information on the nature of gene action controlling the traits under consideration. Lines showed higher $ó_{GCA}^2$ than tester for ascorbic acid, oleoresin and capsaicin content (Table 4). The estimates of $ó_{SCA}^2$ were higher than $ó_{GCA}^2$ (average) for all the traits. The preponderance of $ó_{SCA}^2$ revealed the predominant role of non-additive gene action governing these traits. The results were further confirmed from the higher magnitude of dominance variance ($ó_D^2$) than additive variance ($ó_A^2$) for all the traits which revealed the involvement of non-additive gene action. Similar non-additive gene actions have also been reported by earlier workers in different studies using F_1 with different genetic materials for ascorbic acid (Srivastava et al. 2005) and capsaicin (Lohithaswa et al. 2001 and Srivastava et al. 2005). The type of gene action observed in the present investigation can be best utilized by deferring selection to the later generations to develop superior open pollinated varieties by advancing segregating material through single seed descent or bulk pedigree method (Sharma and Vidyasagar 2005) or single fruit descent method with one or two intermatings like recurrent selection.

सारांश

टमाटर के विभिन्न जीनप्रारूपों में सहसम्बन्ध एवं पथ विश्लेषण ज्ञात करने के लिए वर्ष 2015–16 में जीकेवीके बैंग्लुरू के अनुसंधान प्रक्षेत्र

पर प्रायोगिक परीक्षण किया गया। परिणाम से यह स्पष्ट हुआ कि पौध लम्बाई, शाखाओं की संख्या, फलों की संख्या, फल भार, फलों की लम्बाई तथा चौड़ाई का उपज से धनात्मक एवं सार्थक सहःसम्बन्ध है जो संकेत देता है कि इन सभी घटकों में उन्नयन सीधे चयन विधि से किया जा सकता है। पथ घटकों के विश्लेषण से यह स्पष्ट हुआ कि फलों की संख्या पौध लम्बाई, औसत फल भार, शाखाओं की संख्या, छिलके की मोटाई, फल की लम्बाई, फल कोष्ठकों की संख्या एवं एस्कार्बिक अम्ल की मात्रा का कुल उपज पर सीधा प्रभाव है। अतः टमाटर के जीनप्रारूपों का चयन तथा इनके उन्नयन करते समय उपरोक्त रूपात्मक घटकों पर अधिक ध्यान देने की आवश्यकता है।

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