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Research Note

Combining Ability Analysis of Yield and Yield Components in Tomato (*Lycopersicum esculentum* Mill.)

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Abstract: The nature of the inheritance of plant height at 60 days, number of flowers per cluster, number of fruits per plant, fruit weight per plant, and number of seeds per fruit was studied from a 10-parent diallel cross of *Lycopersicum esculentum* Mill. Due to their high general combining ability effects, Pusharubi, Bari-4, and Dynasagor parents were suggested for future hybridisation programmes. For yield, the crosses Deshy × Ratan, Deshy × Epoch, Dynasagor × Ratan, Bari-4 × Pusharubi, and Dynamo × Namdhari had good specific combining ability effects and they were recommended because they produce stable performing rare transgressive segregants. A population improvement approach in the form of diallel selective mating or mass selection with concurrent random mating could be used for the exploitation of additive and non-additive gene actions for these characters.

Key Words: General combining ability, specific combining ability, F_1 seeds, yield components, tomato, *Lycopersicum* sp.

Introduction

Identification and selection of flexible parental lines are required to be used in any hybridisation programme to produce genetically modified and potentially rewarding germplasm by assembling fixable gene effects more or less in a homozygous line. Information pertaining to different types of gene action, relative magnitude of genetic variance, and combining ability estimates are important and vital parameters to mould the genetic makeup of tomato crop. This important information could prove an essential strategy to tomato breeders in the screening of better parental combinations for further enhancement. Exploitation of heterosis is primarily dependent on the screening and selection of available germplasm that could be produced by better combinations of important agronomic characters. The entire genetic variability observed in the analysis for each trait was partitioned into its components, i.e. general (GCA) and specific combining ability (SCA) as defined by Sprague (1966) and reciprocal effects as sketched by Griffing (1956). They stated that GCA effects were due to additive type of gene action and SCA effects were due to non-additive (dominant or epistatic) gene action. Several studies of combining ability for yield components are available in many species. Some researchers found the predominancy of GCA to be more important than that of SCA (Khan et al., 1991; Yaqoob et al., 1997), while others suggested that SCA was more important (Ortiz, 2004; Biswas et al., 2005).

Although many commercial cultivars have high agronomic performances, they perform poorly because of some genetic hindrances in diverse cross combinations. Thus crossing in a diallel fashion is the only specific and flourishing approach of measurement for the identification and selection of superior genetically recombined material. The current study was carried out to analyse some important tomato cultivars/genotypes to ascertain the relative performance regarding combining ability effects for yield and its components.

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Materials and Methods

The materials for this study consisted of 10 tomato varieties and their F_1 hybrids including the reciprocals. The 10 varieties used as parents were Deshy, Dynasagor, Dynamo, Namdhari, Ratan, Epoch, Bari-4, Legend, Pusharubi, and Japany (Table 1).

Ten parents were crossed to develop F_1 hybrids. The 100 genotypes ($90F_1$s + 10 parents) were evaluated in a randomised complete block design with 3 replications at the Botanical Garden, Department of Botany, University of Rajshahi, Rajshahi-6205, during the growing season of 2003-2004. The unit plot size was 75 × 3 m, maintaining a spacing of 75 cm from row to row and 25 cm from plant to plant. Necessary ploughing and cross ploughing followed by laddering were done to obtain a good tilt. Weeds and other stubbles were removed from the experimental plots and levelled by proper laddering. Necessary intercultural operations were done as needed for good crops. All of the parents and F_1s were used in the study to determine the plant height at 60 days (PH60D), number of flowers per cluster (NFPC), number of fruits per plant (NFPP), fruit weight per plant (FWPP), and number of seeds per fruit (NSPF). Combining ability analysis was carried out according to Singh and Chaudhary (1979) based on Griffing's (1956) fixed effect model using the following formula:

$$Y_{ij} = m + g_i + g_j + s_{ij} + r_{ij} + 1/bc\ \Sigma\Sigma_{ijkl}$$

where i, j = 1, 2.........n; k = 1, 2,......b. l = 1, 2, ...c; Y_{ij} is the mean of i × j genotype over k and l; g_i is the GCA effect of the i^{th} parent; g_j is the GCA effect of the j^{th} parent; s_{ij} is the SCA effect; r_{ij} is the reciprocal effect; and 1/bc SS $_{ijkl}$ is the mean error effect.

Table 1. Ten parental genotypes of tomato with corresponding character.

SL. No.	Genotypes	Description/Identifying Characters
1.	Deshy	The growth of this variety was indeterminate. The leaves of this variety were bigger. The calyx was bigger. The fruits were big and round. In ripening, the fruits were deep red.
2.	Dynasagsr	The growth of this variety was indeterminate. The leaves of this variety were bigger. All flowers developed fruit that were medium sized and long. In ripening, the fruit were yellow red.
3.	Dynamo	The growth of this variety was indeterminate. The stem of this variety was pink and the rate of disease susceptibility was low. The fruit were small and round. The fruit were light red.
4.	Namdhari,	The growth of this variety was determinate. The leaves of this variety were arranged closely. All flowers developed fruit. The fruit were medium-sized and long. In ripe fruit, the colour was yellow red.
5.	Ratan	The growth of this variety was indeterminate. The fruit were medium sized and wrinkled. Ripe tomatoes were deep red.
6.	Epoch	The growth of this variety was determinate. The rate of disease susceptibility of this variety was very high and they were infected by leaf curl. The fruit were round and medium-sized.
7.	Bari-4	The growth of this variety was determinate. Leaves were light green and small. The fruit were medium-sized and orange red .
8.	Legend	The growth of this variety was indeterminate. The plants were healthy, disease susceptibility rate was low, and the stems were pink. The fruit were small and wrinkled.
9.	Pusharubi	The growth of this variety was indeterminate. All stems were pink. Disease susceptibility rate was high. The fruit were large and round.
10.	Japany	The growth of this variety was indeterminate and its growth was not high. The leaves of this variety were arranged closely. The fruit were big and round and ripe fruit were pinkish red

Results and Discussion

Both GCA and SCA were found to be highly significant but the latter has more fruits per plant, flowers per cluster, and fruit weight per plant (Table 2). These observations indicated the importance of both additive and non-additive gene actions in controlling the inheritance of yield and yield components characters, with a major effect of the latter.

Estimates of GCA effects of the parents along with their mean values are presented in Table 3. Bari-4 was found to be the only good combiner for all characters and Dynasagor was found to be a good combiner for plant height at 60 days, number of flowers per cluster, number of fruits per plant, and fruit weight per plant. On the other hand, regarding the plant height at 60 days, number of fruits per plant, and number of seeds per fruit, Pusharubi was observed to be a good combiner. Since high GCA effect is related to additive and additive × additive interaction and represents the fixable components of genetic variance, Bari-4, Dynasagor, and Pusharubi could be used effectively in breeding for high yield, which is supported by Geleta et al. (2006).

Normally SCA effects do not contribute much to the improvement of self-pollinated crops. However, the crosses showing desirable specific, along with good general, combining ability could be utilised in breeding programmes. Such programmes would be more effective if the 2 of the parents are a good combiner and the other one is a poor combiner. In such a situation, they are expected to produce desirable transgressive segregates if the additive genetic system in the good combiner and complementary epistatic effects present in the cross acts in the same direction so as to maximise desirable plant attributes (Salimath & Bahl, 1985). According to Jinks

Table 2. Analysis of variance for combining ability for yield components.

Variance due to	df	Mean square				
		PH60D	NFPC	NFPP	FWPP	NSPF
GCA	9	451.42**	1.36**	67.44**	2.09**	27940.65**
SCA	45	5004.35**	129.6**	1648.56**	15.07**	226760.9**
Reciprocal	45	408.2**	1.55**	96.68**	2.18**	43957.17**
Error	198	0.205	0.246	3.80	0.205	1769.84

** Significant at 1% level

Table 3. Estimation of GCA effects for yield components in 10 varieties of tomato.

Parent	PH60D	NFPC	FPP	FWPP	NSP3F
Deshy	+1.22	-0.03	-1.99	+0.43	-0.32
Dynasagor	+0.799	+0.16	+0.984	+0.19	-12.57
Dynamo	-3.147	+0.29	+0.78	-0.18	+11.30
Namdhari	+2.74	-0.23	-0.59	-0.29	+5.07
Ratan	-0.75	-0.16	-0.03	+0.40	+0.09
Epoch	-4.00	+0.18	-0.49	-0.31	-86.30
Bari-4	+3.98	+0.47	+3.614	+0.37	+27.39
Legend	+3.94	+00	-0.60	-0.10	+25.90
Pusharubi	+5.47	-0.15	+1.30	-0.30	+53.10
Japany	-10.30	-0.20	-3.00	-0.30	-24.00

(1983), the prerequisite for a high, uniform, and stable heterotic effect is the correct gene content, which can be assembled in the homozygous state or if the appropriate alleles are completely dominant as a heterozygote without affecting performance. Based on these findings, Dynamo × Namdhari and Namdhari × Legend for number of flowers per cluster; Deshy × Namdhari, Dynamo × Pusharubi and Bari-4 × Pusharubi for fruits per plant; Deshy × Ratan, Deshy × Epoch and Dynamo × Legend for fruit weight per plant can be used to isolate desirable segregates for the respective characters (Table 4). In the light of the results, for high SCA presented here,

Table 4. SCA and reciprocal effects of ten-parent diallel cross in tomato.

Cross	Characters									
	PH60D		NFPC		FPP		FWPP		NSPF	
	SCA	R	SCA	R	SCA	R	SCA	R	SCA	R
Deshy × Dynasagor	1.07	0.88	0.01	-0.17	-3.74	-6.70	-0.7	-0.49	114	222
Deshy × Dynamo	-2.20	13.9	-0.7	-0.33	3.94	-4.21	-0.2	-0.84	-127	-64
Deshy × Namdhari	2.14	8.25	0.66	0.75	8.19	7.50	0.22	0.79	66.1	-134
Deshy × Ratan	2.42	9.21	0.56	-0.75	1.70	-2.53	1.18	1.57	-55	171
Deshy × Epoch	8.82	18.5	-0.01	00	2.50	1.77	1.22	2.23	108	99.2
Deshy × Bari-4	9.32	11.6	0.55	-0.15	-1.69	-9.35	0.57	-0.06	48.5	45.0
Deshy × Legend	-7.80	4.52	-1.30	0.69	-3.60	11.8	-0.1	0.52	99.9	338
Deshy × Pusharubi	4.19	-4.1	0.09	0.44	-0.40	6.63	-0.2	0.39	-147	-28
Deshy × Japany	-8.70	16.8	-0.30	-0.07	0.76	9.52	-0.5	0.74	-50	-3.5
Dynasagor × Dynamo	-11.2	15.3	1.18	1.26	5.67	-1.20	0.67	-0.53	-67	-8.6
Dynasagor × Namdhari	0.90	-9.7	-0.39	0.66	-3.99	8.53	0.11	0.43	77.2	-147
Dynasagor × Ratan	-5.81	-0.2	0.41	0.37	2.17	1.44	0.67	-0.75	-126	86.3
Dynasagor × Epoch	3.33	4.85	0.94	-1.59	1.98	4.03	0.40	1.47	23.5	24.3
Dynasagor × Bari-4	5.96	3.22	0.76	0.52	6.40	-3.80	0.41	-0.81	-28	-44
Dynasagor × Legend	-4.74	-2.7	-0.52	-0.62	0.53	3.00	0.23	0.03	32.8	-25
Dynasagor × Pusharubi	8.75	-4.3	-1.05	-0.92	1.13	1.72	-0.1	0.45	143	-70
Dynasagor × Japany	5.01	-0.7	0.13	-0.20	-2.80	0.22	0.08	-0.02	64.3	-17
Dynamo × Namdhari	17.17	-20	0.39	-0.43	2.88	-5.50	0.35	0.09	235	-262
Dynamo × Ratan	18.17	-9.0	-0.25	0.50	-0.41	-7.80	-0.6	0.01	17.1	-53
Dynamo × Epoch	-10.2	6.25	0.07	0.66	-6.71	4.51	-0.4	0.78	-56	-46
Dynamo × Bari-4	-3.31	-5.8	0.53	0.92	-4.12	-6.20	0.03	-0.20	152	162
Dynamo × Legend	1.99	-20	0.55	0.58	0.79	-3.10	1.09	-0.90	-127	-32
Dynamo × Pusharubi	0.85	-11	0.025	-0.29	3.82	0.67	0.30	-0.10	165	-83
Dynamo × Japany	-0.59	9.54	-1.00	-0.20	-0.90	6.17	-0.4	0.56	5.86	128
Namdhari × Ratan	-1.82	2.35	-1.06	-0.33	-0.38	1.57	-0.4	0.52	-128	-66
Namdhari × Epoch	-2.62	3.75	-0.49	-0.92	0.66	1.45	0.07	-0.47	22.7	-22
Namdhari × Bari-4	-10.1	21.3	-0.12	5.00	-4.70	2.33	0.04	0.72	15.3	251
Namdhari × Legend	9.05	12.6	0.66	0.50	2.81	-2.53	0.36	0.12	-83	00
Namdhari × Pusharubi	-3.37	-20	0.26	00	5.29	1.23	0.24	-0.38	-121	-39
Namdhari × Japany	-2.81	10.9	-0.30	-0.08	-2.10	1.15	-0.1	0.25	87.6	-147
Ratan × Epoch	8.99	10.4	0.027	1.17	6.07	2.62	-0.3	-0.10	-4.3	-2.8
Ratan × Bari-4	-11.7	-4.9	0.15	0.55	-2.58	-5.53	-0.5	-0.20	91.4	-5.0
Ratan × Legend	0.69	-5.7	-0.40	-0.50	0.41	-4.77	-0.8	-0.10	30.8	57.0
Ratan × Pusharubi	-2.56	-0.3	0.27	-0.25	-5.13	-1.91	0.06	0.57	153	13.8
Ratan × Japany	3.59	13.2	0.10	-0.75	-1.50	-2.30	0.58	0.60	33.7	40.5
Epoch × Bari-4	-11.3	4.53	-1.21	-0.56	0.513	-8.30	0.57	-2.01	-81	62
Epoch × Legend	4.59	-12	0.35	-0.61	0.69	-1.93	-0.5	-0.12	-38	-28
Epoch × Pusharubi	-2.99	-3.6	0.35	-0.50	-5.73	2.15	-0.2	-0.24	-38	-97
Epoch × Japany	0.37	1.65	0.30	-0.15	3.11	1.33	-0.3	-0.28	-17	-74
Bari-4 × Legend	2.46	-7.3	-0.50	00	2.57	2.33	-0.8	-0.45	-118	12.5
Bari-4 × Pusharubi	12.72	-4.4	-0.42	-0.03	11.4	-2.13	0.83	1.01	-8.9	25.6
Bari-4× Japany	0.06	8.27	0.40	1.25	1.01	5.67	0.89	0.54	54.1	166
Legend × Pusharubi	4.43	8.58	0.43	0.27	-1.77	4.48	-0.2	-1.2	-7.3	62.2
Legend × Japany	0.25	8.51	0.50	-0.20	6.35	0.18	0.15	-0.1	-12	115
Pusharubi × Japany	-4.71	10.4	-8.00	0.33	-2.4	-2.58	-2.1	-0.07	-36	49.2

SCA = Specific combining ability, R = Reciprocal intermating among different segregates isolated from the aforementioned crosses may be suggested as a method for improvement in the production of better yield in *L. esculentum* Mill.

Among 90 hybrids, the highest SCA for fruit weight per plant was recorded in Deshy × Epoch followed by Deshy × Ratan, Dynamo × Legend, Deshy × Bari-4, and Dynasagor × Epoch. These crosses involving one good combiner and one average or poor combiner showed positive SCA effects. The cross population with high GCA and SCA effects holds promise for producing desirable segregants in cultivated potatoes. The crosses having one parent with high GCA effects and the other parent with low or average are expected to produce desirable transgress segregates if an additive genetic system present in the high combiner and complimentary epistatic effects present in the cross combination act in the same direction.

Since both additive and non-additive variances were found to be important in the genetic control of all 5 yield component characters in the present study, the use of a population improvement method in the form of diallel selective mating (Jensen, 1970) or mass selection with concurrent random mating (Redden & Jensen, 1974) might lead to release of new varieties with higher yield in *L. esculentum* Mill.

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