Khulna University Studies Volume 19(2): 50-56 : 2022

ORIGINAL ARTICLE

LIFE SCIENCE

STUDY ON GENETIC PARAMETERS IN SELECTED PARENTS AND THEIR HYBRIDS OF TOMATO (*SOLANUM LYCOPERSICUM* L.)

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KUS: 22/45: 14102022

Manuscript submitted: October 14, 2022 Accepted: November 30, 2022

Abstract

A total of 12 diverse tomato genotypes as parents and their 32 hybrids, obtained through Line × tester mating fashion, were evaluated to observe the consequence of different genetic parameters on yield contributing traits. The experiment was conducted during two consecutive years of the 2016-2017 and 2017-2018 winter seasons in a Randomized Complete Block Design (RCBD) with three replications. The analysis of variance (ANOVA) revealed highly significant differences for all the characters, suggesting the presence of genetic variation among the parents. In parents, the highest GCV and PCV were observed 48.94 and 49.10 for fruits plant^{-1}, 39.40 and 39.77 for yield plant^{-1}, and 29.32 and 29.49 for fruits cluster^{-1}, respectively. In hybrids, the higher level of GCV was observed for yield plant^{-1} (35.62), fruits plant^{-1} (25.83), individual fruit weight (24.73), cluster plant^{-1} (21.79), and of PCV for yield plant^{-1} (35.86), fruits plant^{-1} (25.83), individual fruit weight (24.93), and cluster plant^{-1} (21.79). The heritability ranged between 83.92-100% in parents and 99.38-100% in hybrids for most of the traits which denotes a higher level of heritability. The GA as % of mean was higher (>10%) for most of the characters except for days to maturity in parents (9.91) and in hybrids (10.19). According to the per se performance, the promising parents were G_{10}, G_4, G_9, G_8, G_7, G_6, G_{14}, G_1, and hybrids were $G_7 \times G_{14}$, $G_8 \times G_{14}$, $G_{10} \times G_6$, $G_{10} \times G_{12}$, and $G_9 \times G_1$ based on their yield plant^{-1} which could be used as elite varieties of tomato.

Keywords: Tomato, parents, hybrids, genetic parameters, selection

Introduction

Tomato (*Solanum lycopersicum* L.) belongs to the family *Solanaceae* is a commonly grown vegetable crop cultivated worldwide for its fleshy fruits. It has an amusing source of therapeutic nature against cancer and heart diseases due to its higher content of different vitamins, minerals, and strong antioxidants (Dhaliwal *et al.,* 2003). It is also a rich source of polyphenolic compounds, such as flavonoids and hydroxyl cinnamic acids (Bugianesi *et al.,* 2004). Tomato is one of the most economically important vegetable crops for diversified uses like salads, pickles, canned food, paste, ketchup, sauce, puree, and fruit. Considering the nutritional value and various uses of tomato, creation of variation for developing new traits is always a key component in a breeding program. Wild relatives are more genetically diverse compared to cultivate ones (Ghosh *et al.,* 2010). Attention has been paid to combining novel genes in cultivated species from wild ones for extended shelf life and different biotic and abiotic stresses of tomato (Tigchelaar, 1986). Heritability is the measure of the correspondence between breeding values and phenotypic values, (Falconer and Mackay 1996). Thus, heritability plays an important role in breeding and expresses the reliability of phenotype as a guide to its breeding value. The breeding value determines how much of the phenotype would be passed onto the next generation (Tazeen *et al.,* 2009). Genetic advance is the term used to describe the link between heredity and response to selection. High heritability with high genetic advance estimates offers the utmost operative form for selection (Larik *et al.,* 2000). In order to quantify the quantity of genetic gain in a character obtained under certain selection pressure, genetic progress is estimated. Genetic advancement is a further crucial selection factor that supports the breeder in a selection procedure in this way.

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DOI: https://doi.org/10.53808/KUS.2022.19.02.2245-ls

Breeders might choose a trait to be used in breeding programs by considering its heritability, genetic gain, and degree and pattern of variability (Prajapati *et al.,* 2015 and Titus *et al.,* 2020). Therefore, the goal of the current study was to select promising parents and hybrids in order to create commercial cultivars by estimating the level of genetic variability on yield and yield contributing features of parents and their various hybrids.

Materials and Methods

The research was carried out in the Department of Genetics and Plant Breeding experimental field of Sher-E-Bangla Agricultural University, Dhaka during two consecutive winter seasons of 2016-2017 and 2017-2018. Twelve distinct water stress-tolerant tomato genotypes (G_2, G_3, G_4, G_7, G_8, G_9, G_{10}, G_{13}, G_1, G_6, G_{12}, G_{14}) identified by SAU (Begum, 2016) were used in the first year for crossing purposes following the Line × tester design. The genotypes G_2, G_3, G_4, G_7, G_8, G_9, G_{10}, and G_{13} were used as lines, and G_1, G_6, G_{12}, and G_{14} were used as testers. In *Rabi* season of the succeeding year, thirty two F_1 hybrids and their twelve parents were assessed. Thirty days old seedlings were transplanted into the main plot on 20th November of each year. The soil of the experimental field was clay loam with pH 7.3. The experiment was set up following RCBD design with three replications, each with a plot size of 4.0 m^2 and a spacing of 60 by 40 cm on a 1 m wide bed. The recommended fertilizer dose was applied for better crop growth and all necessary agronomic practices were taken on when necessary. Days to initial blooming, duration of maturity, plant height (cm), number of fruits cluster^{-1}, number of cluster plant^{-1}, fruits plant^{-1}, single fruit weight (g), fruit length (mm), and diameter and yield plant^{-1} (kg), (mm) were collected. According to the procedures outlined by Panse and Sukhatme (1985), the analysis of variance (ANOVA) was conducted. Genotypic variance (σ^2g), phenotypic variance (σ^2p), genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability in broad sense (H^2bs), genetic advance (GA) and genetic advance as % mean were analyzed following the formula illustrated by Singh *et al.* (1985) using statistical software program R (version 2.14.0).

Results

Analysis of variance for different characters of tomato parent

At the 1% and 5% probability levels, the analysis of variance showed that the genotypes used for the hybridization program had significantly higher levels of variability for all 10 characters (Table 1). Therefore, genotypes could be selected for the breeding programs for developing hybrids. Bhandari *et al.*, (2017), Patel *et al.,* (2013), and Shashikanth *et al.,* (2010) also predicted similar findings.

Table 1. Analysis of variance for different characters of tomato genotypes used as parents in hybridization

Characters	RMS	GMS	EMS	SEm±	CD@ 5%	CD @ 1%
Days to first flowering	0.18	59.93**	0.09	0.18	0.51	0.70
Days to maturity	0.05	51.77**	0.05	0.13	0.39	0.53
Plant height (cm)	0.05	2359.35**	0.03	0.10	0.29	0.40
Cluster plant^{-1}	0.06	17.16**	0.03	0.09	0.27	0.37
Fruits cluster^{-1}	0.07	5.30**	0.02	0.08	0.24	0.33
Fruits plant^{-1}	9.11	1039.80**	2.25	0.87	2.54	3.45
Fruit length (mm)	2.86	45.42**	2.73	0.95	2.80	3.80
Fruit diameter (mm)	0.01	53.73**	0.01	0.03	0.08	0.11
Individual fruit weight (g)	0.04	172.93**	0.02	0.08	0.24	0.33
Yield plant^{-1} (kg)	0.01	0.55**	0.01	0.02	0.06	0.09

RMS= Replication mean square, GMS= Genotype mean square, EMS= Error mean square, SEm= Standard error of mean, CD= Critical difference.

Performance of parents

The mean performance of 12 parents (8 lines and 4 testers) for their ten yield contributing traits is presented in Table 2. The mean yield performance was (1.07 kg fruit yield plant^{-1}) which was lower than the arithmetic mean of the yield of genotypes G_7 (1.72 kg fruit yield plant^{-1}), G_8 (1.66 kg fruit yield plant^{-1}), G_{10} (1.66 kg fruit yield plant^{-1}), and G_4 (1.21 kg fruit yield plant^{-1}). The genotypes having high mean values for other traits compared to the mean would be used as a promising material for the selection with increased yield potential as well as for other yield contributing traits.

Table 2. Mean performance of tomato genotypes used as parents for yield and yield contributing traits

Parent	Days to first blooming	Duration of maturity	Plant height (cm)	Cluster plant^{-1}	Fruits cluster^{-1}	Fruits plant^{-1}	Fruit length (mm)	Fruit dia. (mm)	Fruit weight (g)	Yield plant^{-1} (kg)
G2	31.00	85.33	59.5	4.50	4.16	18.72	30.36	32.67	34.80	0.65
G3	25.83	87.66	73.83	5.16	5.50	28.38	26.82	30.48	30.70	0.87
G4	30.66	81.66	132.33	9.16	4.66	42.68	34.46	35.22	28.33	1.21
G7	29.66	83.66	88.50	10.33	6.50	67.14	30.22	29.60	25.65	1.72
G8	24.16	84.33	120.50	12.66	6.33	80.13	26.66	27.38	20.76	1.66
G9	33.50	90.16	75.50	8.33	3.66	30.48	34.04	30.70	30.65	0.93
G10	35.50	95.16	122.33	8.66	4.16	36.02	36.25	40.53	45.90	1.65
G13	39.33	90.16	82.83	7.66	4.66	35.69	28.46	27.72	25.25	0.90
G1	31.40	86.16	120.66	9.16	2.83	25.92	30.86	32.44	40.33	1.04
G6	28.00	85.33	131.66	10.33	2.33	24.06	30.16	28.10	20.50	0.49
G12	32.16	82.66	100.50	7.33	5.50	40.31	27.22	28.22	24.68	0.99
G14	25.16	81.66	55.33	5.33	3.16	16.84	22.24	24.32	31.60	0.53
Mean	30.57	86.14	96.89	8.28	4.52	38.00	30.11	30.61	29.89	1.07
SE	0.17	0.13	0.99	0.09	0.08	0.87	0.95	0.03	0.08	0.02
CD@5%	0.51	0.39	0.29	0.27	0.24	2.54	2.80	0.08	0.24	0.06
CD@1%	0.70	0.53	0.40	0.37	0.33	3.45	3.80	0.11	0.33	0.09
Min.	23.66	81.16	55.00	4.33	2.33	16.84	22.24	24.32	20.50	0.49
Max.	39.83	95.50	132.35	12.83	6.83	80.13	38.42	40.54	45.90	1.78

SE= Standard error, CD= Critical difference.

Genetic variability in parents

The performance of different genotypic parameters like the range of mean performance, genotypic and phenotypic variance heritability are presented in Table 3. The highest range of variability was observed for height of plant (55.0-132.35) then the number of fruits plant^{-1} (16.84-80.13), individual fruit weight (20.50-45.90), fruit length (22.24-38.42), fruit diameter (24.32-40.54), days to initial blooming (23.66-39.83), and duration of maturity (81.16-85.50). In the case of variance, the highest genotypic variance was observed for plant height (786.44) followed by fruits plant^{-1} (345.85), individual fruit weight (57.64), and for yield plant^{-1} the lowest genotypic variance (0.18) was observed followed by fruit cluster^{-1} (1.76) and cluster plant^{-1} (5.71). Similarly, the phenotypic variance was also the highest for height of the plant height (786.47) followed by fruits plant^{-1} (348.10), individual fruit weight (57.66), and the least genotypic variance was observed for yield plant^{-1} (0.18) followed by fruit cluster^{-1} (1.78) and cluster plant^{-1} (5.74).

The characters with significant genotypic variance suggest that more genetic factors contributed to the overall variation. Therefore, these characters could be taken into account and used as selection criteria. These outcomes matched those that had been revealed by Mohanty *et al.,* (2002), Lecome *et al.,* (2004), Hyder *et al.,* (2007), Ghosh *et al.,* (2010), Bernousi *et al.,* (2011), Manna *et al.,* (2012), Naik *et al.,* (2012), Patel *et al.,* (2013), Agrawal *et al.,* (2014) and Khapte *et al.,* (2014).

The phenotypic coefficient of variation (PCV) ranged from 4.83 to 49.10, while the genotypic coefficient of variation (GCV) of all the characteristics ranged from 4.82 to 48.94 (Table 2). The highest phenotypic coefficient of variation was observed for fruits plant^{-1} (49.10), yield plant^{-1} (39.77), fruits cluster^{-1} (29.49), plant height (28.95), and cluster plant^{-1} (28.90). Similarly, the highest genotypic coefficient of variation (GCV) was observed for fruits plant^{-1} (48.94), yield plant^{-1} (39.40), fruits cluster^{-1} (29.32), plant height (28.94), and cluster plant^{-1} (28.84). Mohamed *et al.* (2012), Patel *et al.* (2013), Santader *et al.* (2013), Lecome *et al.* (2004), Shashikant *et al.* (2010), Bernousi *et al.* (2011), and Agrawal *et al.* (2014) also reported similar results. For all the traits, the genotypic coefficient of variation (GCV), the accurate measure of the degree of genetic variability in a population, was high with the exception of days to maturity (4.82). Generally, PCV values were higher than GCV values for all traits indicating the higher magnitude of variability for these characters. The findings are in conformity with Khapte *et al.* (2014), Ghosh *et al.* (2010), Hyder *et al.* (2007), Shashikant *et al.* (2010), Bernousi *et al.* (2011), Manna *et al.* (2012), and Agrawal *et al.* (2014).

Table 3. Different genetic parameters for ten quantitative traits in tomato genotypes used as parents in hybridization

Characters	Range		Mean	Variance		GCV (%)	PCV (%)	H^2 (bs)	GA (%)	GA as % of mean
	Min	Max		σ^2 g	σ^2 p					
Days to initial blooming	23.66	39.83	30.57	19.95	20.04	14.61	14.64	99.54	9.18	30.02
Duration of maturity	81.16	95.50	86.14	17.24	17.29	4.82	4.83	99.69	8.54	9.91
Plant height (cm)	55.00	132.35	96.89	786.44	786.47	28.94	28.95	100	57.77	59.63
Cluster plant^{-1}	4.33	12.83	8.29	5.71	5.74	28.84	28.90	99.56	4.91	59.28
Fruits cluster^{-1}	2.33	6.83	4.52	1.76	1.78	29.32	29.49	98.85	2.72	60.05
Fruits plant^{-1}	16.84	80.13	38.00	345.85	348.10	48.94	49.10	99.35	38.19	100.48
Fruit length (mm)	22.24	38.42	30.11	14.23	16.96	12.53	13.68	83.92	7.12	23.64
Fruit diameter (mm)	24.32	40.54	30.61	17.90	17.91	13.82	13.83	99.99	8.72	28.48
Single fruit weight (g)	20.50	45.90	29.89	57.64	57.66	25.39	25.40	99.96	15.64	52.31
Yield plant^{-1} (kg)	0.49	1.78	1.08	0.18	0.18	39.40	39.77	99.12	0.87	81.21

σ^2g= Genotypic variance, σ^2p= Phenotypic variance, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, H^2bs= Heritability in broad sense, GA= Genetic advance.

Three types of heritability are suggested by Johnson *et al. (*1955) high (above 60%), medium (30%-60%), and low (below 30%). The highest heritability was recorded in all the characters studied and ranged between 83.92 and 100 (table 2). Though high heritability estimates have been found to be helpful in making a selection of superior genotypes on the basis of phenotypic performance, Johnson *et al.* (1955) also suggested heritability estimates coupled with the high genetic advance in the percentage of mean would be more useful in predicting selection of the best individual. It is classified as low less than 10%, moderate 10-20%, and high more than 20% by Johnson *et al.* (1955). Here most of the characters showed high genetic advance as % of mean except days to maturity performed low (9.91%). High genetic progress as a percentage of mean and high heritability suggests that choosing such features should be quite simple. Because the environment contributes less to the phenotype than the genotype. As a result, it would be feasible to apply a straightforward selection approach based on phenotype, which would ultimately enhance the genetic basis of these traits. Sharmin *et al.* (2019), Meena *et al.* (2015), Nwosu *et al.* (2015), and Dutta *et al.* (2018) also cited similar findings.

Per se performance of hybrids

The performance of the hybrids is based on each of the traits assessed, on the basis of average data, the means and their standard errors are calculated, and they are summarized in Table 4. For all the attributes examined, tomato hybrids generally displayed a large range of variability, with all ranges between the maximum and minimum mean values. Days to maturity, for instance, ranged from 78.33 to 95.28 with a mean of 86.57, and days to first flowering ranged from 25.52 to 40.55 with a mean of 32.77. In a similar manner, the height of plant and cluster plant^{-1} ranged from 60.14 to 135.48 and 4.32 to 9.48 respectively. The maximum fruit yield plant^{-1} obtained was $G_7 \times G_{14}$ (2.17) followed by $G_8 \times G_{14}$ (2.01), $G_{10} \times G_6$ (1.72), $G_{10} \times G_{12}$ (1.45), and $G_9 \times G_1$ (1.32)) and range varied between 0.40 and 2.19 via means of 1.06. So, it is feasible to increase fruit yield through direct selection as suggested by Saleem, *et al.* (2013), and Meena *et al.* (2015).

Table 4. Performance of 32 distinct crosses (hybrids) for qualities that contribute to tomato yield on their own

Hybrids	Days to first blooming	Duration of maturity	Plant height (cm)	Cluster plant^{-1}	Fruits cluster^{-1}	Fruits plant^{-1}	Fruit length (mm)	Fruit dia. (mm)	Fruit weight (g)	Yield plant^{-1} (kg)
$G_2 \times G_1$	30.33	82.46	90.63	4.33	4.22	26.71	32.65	34.80	36.56	0.66
$G_3 \times G_1$	29.65	85.44	92.44	5.54	4.64	25.70	35.20	32.65	35.66	0.92
$G_4 \times G_1$	32.40	88.45	110.55	6.54	4.30	28.12	32.45	34.44	36.45	1.02
$G_7 \times G_1$	36.29	90.44	100.34	6.55	5.60	36.73	30.37	32.65	35.55	1.30
$G_8 \times G_1$	25.54	82.44	95.64	5.46	4.44	24.24	36.26	40.51	48.64	1.17
$G_9 \times G_1$	32.40	85.65	96.44	8.45	4.32	36.50	32.65	34.80	36.66	1.32
$G_{10} \times G_1$	40.24	90.24	100.36	6.44	3.56	22.92	40.24	42.32	45.56	1.04
$G_{13} \times G_1$	38.45	90.44	95.65	7.45	3.62	49.31	30.34	32.44	40.44	1.08
$G_2 \times G_6$	32.43	82.46	110.55	7.65	4.32	33.08	32.22	35.43	28.65	0.95
$G_3 \times G_6$	30.54	85.36	100.34	4.45	4.64	20.64	30.32	32.44	35.32	0.73
$G_4 \times G_6$	28.63	84.55	130.56	8.84	4.56	40.31	22.22	25.32	32.44	1.44
$G_7 \times G_6$	32.46	87.45	120.64	7.46	4.45	33.19	26.43	30.72	30.32	1.04
$G_8 \times G_6$	26.44	80.64	135.45	7.54	4.54	34.23	28.43	27.34	30.22	1.03
$G_9 \times G_6$	31.34	82.45	105.75	6.44	4.32	27.82	27.54	24.44	25.27	0.70
$G_{10} \times G_6$	36.26	90.46	130.34	7.88	4.54	35.77	36.63	40.55	48.32	1.72
$G_{13} \times G_6$	36.34	92.46	109.45	6.64	4.56	30.27	30.24	28.32	20.18	0.61
$G_2 \times G_{12}$	34.24	90.45	80.64	4.45	5.54	24.65	34.34	30.45	30.32	0.74
$G_3 \times G_{12}$	28.34	80.44	90.45	6.65	4.64	30.85	33.44	34.33	28.24	0.87
$G_4 \times G_{12}$	30.46	85.64	120.34	8.32	4.40	36.60	28.35	30.34	25.63	0.94
$G_7 \times G_{12}$	35.26	88.56	95.35	9.45	4.64	43.84	24.45	23.44	22.32	0.97
$G_8 \times G_{12}$	28.44	78.35	95.64	7.66	5.56	42.58	22.42	24.32	24.42	1.03
$G_9 \times G_{12}$	38.34	87.65	80.44	8.44	4.36	36.79	24.65	24.56	25.64	0.94
$G_{10} \times G_{12}$	40.44	95.25	92.34	6.66	4.32	28.77	40.46	42.44	50.54	1.45
$G_{13} \times G_{12}$	40.53	92.35	85.46	4.54	5.54	25.15	32.44	33.34	34.32	0.86
$G_2 \times G_{14}$	28.34	82.36	60.15	4.40	5.34	23.49	27.32	30.45	32.22	0.75
$G_3 \times G_{14}$	30.64	84.54	70.44	4.42	3.22	14.23	33.45	34.44	28.54	0.41
$G_4 \times G_{14}$	28.25	83.35	100.46	7.45	4.54	33.82	28.32	28.34	30.32	1.02
$G_7 \times G_{14}$	30.43	82.34	80.65	8.45	5.55	46.89	40.32	42.44	46.55	2.17
$G_8 \times G_{14}$	30.45	85.54	90.45	8.64	5.48	47.34	38.55	40.56	42.32	2.01
$G_9 \times G_{14}$	32.26	87.24	72.55	7.42	4.44	32.94	22.32	22.44	28.34	0.93
$G_{10} \times G_{14}$	36.16	94.24	100.34	6.45	3.56	22.96	32.54	36.56	50.44	1.15
$G_{13} \times G_{14}$	36.26	90.36	75.64	6.22	5.45	33.89	26.34	25.22	27.32	0.92
Mean	32.77	86.57	97.39	6.79	4.60	31.24	31.06	32.28	34.31	1.06
SE	0.01	0.01	0.01	0.01	0.01	0.10	0.02	0.02	0.63	0.03
CD@%	0.03	0.03	0.03	0.02	0.03	0.27	0.04	0.05	1.78	0.07
CD@%	0.04	0.04	0.04	0.03	0.04	0.36	0.06	0.07	2.36	0.10
Min.	25.52	78.33	60.14	4.32	3.20	14.21	22.21	22.42	20.17	0.40
Max.	40.55	95.28	135.48	9.48	5.62	47.46	40.48	42.46	50.56	2.19

SE= Standard error, CD= Critical difference.

Variability in hybrids

Different genotypic parameters were estimated for all the studied traits in hybrids have been shown in (Table 5). High heritability was observed for all the traits. For traits like cluster plant^{-1}, fruits plant^{-1}, individual fruit weight, and yield plant^{-1} that showed substantial GCV, PCV, and genetic advancement as % of mean, indicates direct selection may be applied.

Table 5. Ten quantitative features in tomato hybrids have various genetic factors

Characters	Range		Mean	Variance		GCV	PCV	H^2	GA	GA as%
	Min.	Max.		σ^2 g	σ^2 p	(%)	(%)	(bs)	(%)	of mean
Days to first flowering	25.52	40.55	32.77	17.42	17.42	12.74	12.74	100	8.60	26.24
Days to maturity	78.33	95.28	86.57	18.32	18.32	4.94	4.94	100	8.82	10.19
Plant height (cm)	60.14	135.48	97.39	313.17	313.17	18.18	18.17	100	36.46	37.43
Cluster plant^{-1}	4.32	9.48	6.79	2.19	2.19	21.79	21.79	99.99	3.05	44.88
Fruits cluster^{-1}	3.20	5.62	4.60	0.40	0.40	13.75	13.75	99.90	1.30	28.30
Fruits plant^{-1}	14.21	47.46	31.24	65.10	65.13	25.83	25.83	99.96	16.62	53.20
Fruit length (mm)	22.21	40.48	31.06	28.85	26.85	16.68	16.68	100	10.67	34.36
Fruit diameter (mm)	22.42	42.46	32.28	35.29	35.29	18.40	18.40	100	12.24	37.91
Single fruit weight (g)	20.17	50.56	34.31	71.98	73.17	24.73	24.93	98.38	17.34	50.52
Yield plant^{-1} (kg)	0.40	2.19	1.06	0.14	0.14	35.62	35.86	98.68	0.77	72.89

σ^2g= Genotypic variance, σ^2p= Phenotypic variance, GCV= Genotypic coefficient of variation, PCV= Phenotypic coefficient of variation, H^2bs= Heritability in broad sense, GA= Genetic advance.

Conclusion

Analysis of variance (ANOVA) revealed significant genetic variability for yield and its constituent parts among the research parents. High genotypic parameters for fruits plant^{-1}, yield plant^{-1}, cluster plant^{-1}, fruits cluster^{-1}, and individual fruit weight were expressed by both the parental genotypes and hybrids, indicating that these traits should be taken into consideration for direct selection. Based on yield plant^{-1} performance alone, the potential hybrids were $G_4 \times G_6$, $G_7 \times G_{14}$, $G_8 \times G_{14}$, $G_{10} \times G_6$ and $G_{10} \times G_{12}$. Among the hybrids, $G_7 \times G_{14}$ and $G_8 \times G_{14}$ had better performance compared to their parents.

Acknowledgment

The authors would like to acknowledge the University Grants Commission (UGC), Government of Bangladesh for providing fellowship to carry out this research project as well as Sher-e-Bangla Agricultural University for providing land and other experimental facilities during this study.

Conflict of Interests

The author declares no conflict of interest.

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