J Plant Mol Breed (2019) 7(2): 50 - 62
DOI: 10.22058/JPMB.2021.529898.1231

RESEARCH ARTICLE

Diallel analysis of combining ability and heterosis for yield and yield attributes in groundnut (*Arachis hypogaea* L.)

Md. Rayhan Sikder[1,2], Md. Abul Kalam Azad[2] and Mohammad Anwar Hossain[1*]

[1]Department of Genetics and Plant Breeding, Faculty of Agriculture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[2]Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh

ABSTRACT: Groundnut (*Arachis hypogaea* L.) is one of the major oilseed crops of the world and it is an important source of protein in many countries. To study the nature of combining ability and heterosis for yield and related attributes a 4 × 4 full diallel experiment was conducted at the experimental plot of Bangladesh Institute of Nuclear Agriculture, Mymensingh, Bangladesh. Data on various quantitative traits including yield were recorded. Significant differences among the parents and their hybrids were observed for yield and related traits. The analysis of variance for general combining ability (GCA), specific combining ability (SCA) and reciprocal combining ability also showed significant variations for all the studied traits. The GCA and SCA reflected that these traits were controlled by both additive and non-additive genes. Predominant regulation by non-additive gene action suggesting selection at a later generation would be much effective. Significant reciprocal effect for all the traits indicates role of maternal effect in the expression for these traits. Genotypes GC (24)-1-1-1 and China Badam were found suitable combiners for number of seeds per pod, 100-pod weight, 100-seed weight, shelling percentage, and yield per plant. Result of mean and GCA suggested that the genotypes have good ability to transfer these important quantitative traits. The SCA and heterosis revealed that the F_1 obtained from the cross GC (24)-1-1-1 × China Badam was suitable specific combiner among the F_1's for most of the traits. The F_1 may further be exploited for isolating the desirable segregates of these traits for maximizing yield.

KEYWORDS: *Arachis hypogaea*, diallel cross, parents, hybrids, gene action, yield improvement

INTRODUCTION

Groundnut (*Arachis hypogaea* L., 2n=40) is an important self-pollinated, oil, food, and feed legume crop cultivated worldwide. It contains about 45–56% of high quality edible oil, 25–30% protein, 20% carbohydrate, and is a rich source of dietary fiber, minerals, and vitamin E and B [1,2-3]. Bangladesh is the 39th largest groundnut producer and it is third most important oil seed crop after mustard and sesame in Bangladesh [4]. It is cultivated in 35276 ha of land with a total production of 62832 tons during 2018 [5] which is not sufficient for the country's demand. Globally, 49% of produced groundnut is crushed for extraction of oil and 41% is used for food purposes. After oil extraction, the remaining oilcake is used as a protein supplement in livestock feed rations as well as industrial raw material [3]. In Bangladesh, the use of groundnut as direct and processed food products has been expanding day by day however it has little use in oil extraction. Groundnut kernels can be consumed directly

*Corresponding author (✉):anwargpb@bau.edu.bd
Received: 7 May 2021/ Revised: 14 July 2021
Accepted: 1 September 2021

as ready-to-eat products or indirectly as confectionary. The existing groundnut varieties of Bangladesh are mostly two seeded with medium to small seed size. Three varieties having large two seeds were developed by the Bangladesh Institute of Nuclear Agriculture (BINA) [6], however, these varieties failed to get popularity among the groundnut growers due to lower shelling percentage and thicker shells. Therefore, development of high yielding genotypes having appropriate pod and seed characteristics is one of the most important breeding objectives in groundnut. To achieve this objective, the plant breeders must have a working knowledge of the inheritance of economic traits if he would to improve them efficiently.

Breeding of any crop depends on the expanse of genetic variability, gene action and the character transmission from one generation to the next. Different breeding strategies have been suggested for the improvement of groundnut populations for example combining ability analysis and heterosis [7]. The combining ability describes the gene action for desirable traits that may help the breeder to set an appropriate breeding method. Diallel analysis permits to infer the potential of each genitor to provide superior hybrid combinations, the gene action that controls the traits involved, and the existence of heterosis, providing the opportunity to identify and develop superior lines [8]. The general combining ability (GCA) generates information regarding a set of genes of predominantly additive effects, and the specific combining ability (SCA) is related to a set of genes of dominance and epistatic effects [9-10]. The reciprocal combining ability (RCA) denotes genotypic maternal effect. Many researchers showed that yield traits were controlled by additive gene action [1, 11] and some other showed both additive and non-additive gene action [12-14]. Although trait inheritance has been reported, the mechanisms of the inheritance of a trait may be different due to the parent source [15]. The objectives of the present study were to (a) analyze combining ability effect for yield and yield components of the selected genotypes and their hybrids (b) evaluate the magnitude of heterosis to select parents or superior lines and to set an appropriate breeding program to increase yield and quality.

MATERIALS AND METHODS

Experimental site and plant material

The experiment was conducted at the field experimental plot of Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh, Bangladesh during 2018-2020 using a 4 × 4 intra-specific F_1 diallel cross of groundnut. Breeding material comprised of a set of four groundnut genotypes viz., Binachinabadam-4, Dacca-1, GC (24)-1-1-1 and China Badam, having diverse origin. These parents were selected due to their potential morphological traits like higher yield, large seed size and early maturity obtained from our previous studies. Phenotype and other details of the parental lines used in the study are mentioned in Supplementary Table 1 and Figure 1. All genotypes were crossed in complete diallel fashion. During 2019-20, a set of four parents and their 12 F_1 hybrids (6 direct and 6 reciprocal crosses) were evaluated in a randomized complete block design. Each plot was designed as 1.5 m × 5 m in size, consisting of sixteen rows with row length of 1.5 m. Plant to plant and row to row distance were 20 and 30 cm, respectively. All recommended cultural practices and inputs including thinning, hoeing, irrigation and pest control were carried out using the standard procedures.

Data recording and statistical analysis

Data on yield and yield attributes (days to maturity, plant height, primary branches per plant, secondary branches per plant, total pods per plant, mature pods per plant, 100-pod weight, 100-seed weight, seeds per pod, shelling percentage and yield per plant) were recorded from randomly selected 15 plants for three replications of each genotype. The data were subjected to analysis of variance (ANOVA) valid for RCBD design. ANOVA, mean, combining ability and heterosis were calculated by computer using PB tools version: 1.3 of IRRI [16] and Minitab-17 software. Mean separation was done following Duncan's Multiple Range Test (DMRT) at 5% level of probability. Griffing's [17] Model one was used for combining ability (GCA, SCA and RCA) analysis for each of the trait. The amount of heterosis was calculated by comparing the mean of F_1 hybrids over mid-parental value in respect of a particular character using the formulae given by Rai [18].

RESULTS

Analysis of variance

The mean squares (MS) for yield and yield contributing traits were showed highly significant differences ($P \leq 0.01$) among the parents (Table 1).

Table 1. Analysis of variance for yield and yield contributing traits in a 4 × 4 diallel crossing experiment of groundnut.

Item	df	DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
Replication	2	7.65	18.37	1.08	0.33	3.40	2.27	0.02	16.45	3.14	8.57	0.15
Genotype	15	15.87**	74.79**	5.79**	1.23**	194.12**	100.35**	0.52**	899.05**	504.80**	212.52**	268.11**
Error	30	2.15	26.64	1.48	0.16	2.66	1.86	0.01	21.99	4.87	5.48	0.41
CV		0.17	1.18	2.63	4.41	3.63	3.91	1.83	2.26	2.59	1.29	8.20

Note: * and ** indicates significant at 5% and 1% level of probability, respectively.
Here, DM-days to maturity, PH- plant height (cm), PBP- primary branches per plant, SPB- secondary branches per plant, TPP- total pods per plant, MPP- mature pods per plant, NSP-number of seeds per pod, 100- pod weight, 100-seed weight, YPP- yield per plant.

Means values for yield and yield attributing traits of parents and crosses in a 4 × 4 diallel experiment of groundnut

The mean values of yield and yield attributing traits in a 4 × 4 diallel cross of groundnut are shown in Table 2. Among the studied genotypes, the parent China Badam was found to mature earlier however it showed non-significant difference with GC (24)-1-1-1 × Dacca-1 and China Badam × GC (24)-1-1-1. Binachinabadam-4 was the late maturing genotypes. Little variation was observed among the parents and hybrids in terms of days to maturity (Table 2). The parent GC (24)-1-1-1 and Daaca-1 had the highest plant height (49.56 and 49.30 cm, respectively) which did not differ significantly from the hybrids obtained from eight cross combinations. In contrast, the hybrid obtained from the cross combination, China Badam × GC (24)-1-1-1 had the lowest plant height.

In respect of number of primary branches per plant, the parent China Badam had the highest number of primary braches (6.33) per plant that showed a non-significant differences with the cross China Badam × GC (24)-1-1-1 and the cross combination GC (24)-1-1-1 × China Badam. The parent China Badam had the highest (3.33) number of secondary branches per plant which significantly differed from other parent and hybrids. Among the crosses, Binachinabadam-4 × China Badam and China Badam × Dacca-1 showed the highest number of secondary branches per plant (2.33 and 2.0, respectively) (Table 2).

In respect of number of total pods per plant, maximum number of pods was found from the cross combinations GC (24)-1-1-1 × China Badam which showed a non-significant difference with another cross combination GC (24)-1-1-1 × Binachinabadam-4. Among the parents, maximum number of pods per plant was found from the parent GC (24)-1-1-1 and Binachinabadam-4. The minimum number of total pods per plant was found in the cross Dacca-1 × China Badam and in the parent China Badam (7 and 8.33, respectively) (Table 2).

Among the parents, the maximum number of matures pods plant was observed in Binachinabadam-4 (20.00) whereas the lowest (6.66) was found in China Badam. The cross GC (24)-1-1-1 × China Badam exhibited maximum number of mature pods per plant (27.33) whereas the minimum (4.33) was found from the hybrid obtained from the cross Dacca-1 × China Badam (Table 2).

In respect of number of seeds per pod, the cross China Badam × GC (24)-1-1-1 had more than three seeds which showed a non-significant difference with the cross China Badam × Binachinabadam-4 and GC (24)-1-1-1 × China Badam (Table 3). Among the parents, China Badam showed the highest number of seeds per pod (Table 2).

The cross combination GC (24)-1-1-1 × China Badam and its reciprocal cross showed the highest pod weight (117.60 and 110.35g, respectively). The cross combination Dacca-1 × Binachinabadam-4 showed the minimum 100-pod weight (56.48g) although it showed a non-significant difference with the parents (Table 3). In respect to 100-seed weight, the cross GC (24)-1-1-1 × China Badam had the highest 100-seed weight (78.83g) where its reciprocal cross China Badam × GC (24)-1-1-1 showed the next highest (75.65g) however, they had a significant difference (Table 3). On the other hand, the cross combination Dacca-1 × GC (24)-1-1-1 had the highest shelling percentage (72.21%) and the next highest (71.32%) was observed from cross Binachinabdam-4 × China Badam. The lowest shelling percentage was

Table 2. Mean values of yield and yield attributes of parents and the F1 hybrids in a 4×4 diallel crossing experiment of groundnut

Parents	DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
Binachinabadam-4	138.00 ^{a}	40.16 $^{b-e}$	4.00^{e}	1.00 ^{e}	26.33 ^{b}	20.00 ^{c}	1.95 ^{de}	59.36 ^{hi}	39.99 ^{i}	67.38 $^{c-e}$	15.65 ^{de}
Dacca-1	135.0 $^{b-d}$	49.30 ^{a}	4.33 ^{de}	1.00 ^{e}	15.66 ^{h}	12.00 ^{gh}	1.92 ^{e}	61.18 $^{g-i}$	41.61 ^{hi}	67.97 $^{b-e}$	9.60 $^{f-i}$
GC (24)-1-1-1	133.00 ^{de}	49.56 ^{a}	4.00 ^{e}	1.00 ^{e}	25.00 ^{bc}	12.00 ^{gh}	2.16 ^{c}	71.12 $^{d-f}$	45.86 $^{e-g}$	64.85 ^{e}	17.80 ^{d}
China Badam	130.00 ^{f}	36.36 $^{c-e}$	6.33 $^{a-d}$	3.33 ^{a}	8.33 ^{j}	6.66 ^{i}	2.59 ^{b}	68.33 $^{e-g}$	43.25 $^{f-i}$	60.01 ^{f}	5.72 ^{hi}
Crosses											
Binachinabadam-4 × Dacca-1	136.00 $^{a-c}$	46.56 ^{ab}	3.66 ^{e}	1.00 ^{e}	18.66 $^{e-g}$	16.66 ^{de}	1.91 ^{e}	72.97 $^{c-f}$	32.87 ^{j}	45.07 ^{h}	13.71 ^{ef}
Binachinabadam-4×GC (24)-1-1-1	136.66 ^{ab}	41.80 $^{a-e}$	4.00 ^{e}	1.33 ^{de}	17.66 $^{f-h}$	13.00 ^{fg}	2.16 ^{c}	65.70 $^{f-h}$	42.22 $^{g-i}$	69.78 $^{b-d}$	11.70 $^{f-h}$
Binachinabadam-4×China Badam	138.00 ^{a}	47.53 ^{ab}	5.00 $^{c-e}$	2.33 ^{b}	15.33 ^{h}	13.00 ^{fg}	1.88 ^{e}	60.73 $^{g-i}$	43.93 $^{f-h}$	71.32 ^{b}	9.31 $^{f-i}$
Dacca-1× Binachinabadam-4	133.66 $^{c-e}$	42.60 $^{a-d}$	4.00 ^{e}	1.33 ^{de}	21.33 ^{de}	15.00 ^{ef}	1.95 ^{de}	56.48 ^{i}	28.28 ^{j}	50.27 ^{gh}	12.15 $^{d-f}$
Dacca-1 ×GC (24)-1-1-1	133.66 $^{c-e}$	42.53 $^{a-d}$	5.66 $^{b-e}$	1.33 ^{de}	22.33 ^{cd}	18.66 ^{cd}	2.13 ^{cd}	75.85 $^{c-e}$	54.86 $^{e-g}$	72.21 ^{a}	16.26 ^{de}
Dacca-1 × China Badam	137.00 ^{ab}	40.60 $^{b-e}$	5.33 $^{c-e}$	1.66 ^{cd}	7.00 ^{j}	4.33 ^{j}	1.85 ^{e}	80.50 ^{bc}	56.06 ^{c}	57.14 ^{fg}	5.56 ^{i}
GC (24)-1-1-1×Binachinabadam-4	136.66 ^{ab}	48.46 ^{ab}	5.00 $^{c-e}$	1.00 ^{e}	34.33 ^{a}	23.00 ^{b}	2.31 ^{c}	87.41 ^{b}	48.26 ^{de}	58.23 ^{fg}	30.11 ^{b}
GC (24)-1-1-1 Dacca-1	132.33 ^{ef}	41.20 $^{a-e}$	4.66 $^{c-e}$	1.33 ^{de}	20.33 $^{d-f}$	15.00 ^{ef}	2.59 ^{b}	78.05 ^{cd}	41.55 $^{f-i}$	56.01 ^{g}	15.94 ^{de}
GC (24)-1-1-1 ×China Badam	133.66 $^{c-e}$	40.66 $^{b-e}$	7.66 ^{ab}	1.00 ^{e}	36.00 ^{a}	27.33 ^{a}	2.90 ^{a}	117.60 ^{a}	78.83 ^{a}	67.08 $^{c-e}$	42.52 ^{a}
China Badam × Binachinabadam-4	132.66 ^{de}	34.40 $^{d-e}$	6.66 $^{a-c}$	1.00 ^{e}	12.00 ^{i}	10.00 ^{h}	2.94 ^{a}	86.50 ^{b}	43.25 ^{fi}	55.72 ^{g}	10.42 $^{f-i}$
China Badam × Dacca-1	134.00 $^{c-e}$	43.16 $^{a-c}$	5.66 $^{b-e}$	2.00 ^{bc}	16.00 ^{gh}	12.66 ^{g}	1.92 ^{e}	72.02 $^{d-f}$	50.56 ^{d}	70.66 ^{bc}	11.71 $^{f-h}$
China Badam ×GC (24)-1-1-1	132.00 ^{ef}	33.43 ^{e}	8.33 ^{a}	1.66 ^{cd}	22.00 ^{d}	17.33 ^{d}	3.06 ^{a}	110.35 ^{a}	75.65 ^{b}	66.39 ^{de}	24.35 ^{c}
Max.	130.00	31.00	3.00	1.00	6.00	4.00	1.75	54.00	3.30	45.73	4.55
Min.	139.00	61.60	11.00	4.00	38.00	29.00	3.18	120.40	64.40	80.82	45.78

Note: Different letters in the same column indicates significant difference at 5% level of probability following DMRT.

DM-days to maturity, PH- plant height (cm), PBP- primary branches per plant, SPB- secondary branches per plant, TPP- total pods per plant, MPP- mature pods per plant, NSP-number of seeds per pod, 100- pod weight, 100-seed weight, YPP- yield per plant.

Table 3. ANOVA for combining ability of yield and yield contributing traits in a 4 4 diallel crossing experiment of groundnut.

Source of Variation	d f	MS										
		DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
GCA	3	11.52**	43.33**	5.82**	1.23**	154.81**	46.23**	0.39**	579.72**	524.40**	174.27**	150.27**
SCA	6	3.46**	16.21**	1.46**	0.20**	36.27**	35.95**	0.12**	331.29**	134.83**	45.16**	89.95**
RCA	6	3.99**	24.44**	0.45**	0.21**	48.08**	24.55**	0.11**	128.05**	23.63**	44.80**	58.34**
Error	30	0.71	8.88	0.49	0.05	0.90	0.61	0.01	7.21	1.59	1.83	0.13
V_A		16.78	13.84	13.84	0.52	60.63	6.30	158.36	136.67	0.14	21.45	33.61
V_D		732.38	18.05	18.05	0.37	87.00	86.95	980.59	797.73	0.30	45.65	221.09

Note: *and ** indicates significant at 5% and 1% level of probability, respectively.
DM-days to maturity, PH- plant height (cm), PBP- primary branches per plant, SPB- secondary branches per plant, TPP- total pods per plant, MPP- mature pods per plant, NSP- number of seeds per pod, 100- pod weight, 100-seed weight, YPP- yield per plant.

Table 4. General combining ability effect for yield and yield attributing traits of parents in a 4×4 diallel crossing experiment of groundnut.

Character / Parent	DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
Binachinbadam4	1.65**	0.31	-0.72**	-0.21	1.60*	1.54*	-0.13**	-7.95**	-5.17**	0.14	-0.89**
Dacca-1	0.10	2.01	-0.56*	-0.13	-2.77**	-1.50*	-0.24**	-6.73**	-8.63**	-6.62**	-3.84**
GC (24)-1-1-1	-0.69	1.01	0.15	-0.25*	5.44**	2.50**	0.17**	8.14**	6.51**	2.06*	6.21**
China Badam	-1.06	-3.33*	1.14**	0.58**	-4.27**	-2.54**	0.21**	6.53**	7.29**	4.14**	-1.47**
SE (gi)	0.26	0.91	0.12	0.07	0.29	0.24	0.02	0.82	0.38	0.41	0.11

Note: * and ** indicates significant at 5% and 1% level of probability, respectively.
DM- days to maturity, PH- plant height (cm), PBP- primary branches per plant, SPB- secondary branches per plant, TPP- total pods per plant, MPP- mature pods per plant, NSP- number of seeds per pod, 100- pod weight, 100- seed weight, YPP- yield per plant.

observed from the hybrid obtained from cross Binachinabadam-4 × Dacca-1(Table 2). In respect of yield per plant, the hybrid obtained from the cross GC (24)-1-1-1 × China Badam showed the highest yield per plant (42.52g) and its reciprocal cross China Badam × GC (24)-1-1-1 showed the next highest yield (30.11g) but they had a significant difference (Table 3). However, the F_1 hybrids obtained he cross combination Dacca-1 × China Badam showed the lowest yield per plant (5.56 g) among the crosses and parents (Table 2).

Analysis of variance for combining ability

The mean squares for GCA, SCA and RCA were highly significant for yield and yield contributing characters (Table 3). The variances due to dominance deviation (V_D) for yield and yield contributing characters were much higher than the corresponding additive genetic variances (V_A), except secondary branches per plant.

Combining ability effects

The GCA effect of plant height indicated Dacca-1 was the best general combiner followed by GC (24)-1-1-1 and Binachinabadam-4, although they did not differ significantly from each other (Table 4). On the other hand, China Badam was the poorest general combiner. Among the four parents, China Badam was the best general combiner for number of primary branches per plant and number of secondary branches due to the highest positive and significant GCA effect while Binachinabadam-4 and GC (24)-1-1-1 was the poorest general combiner for number of primary branches per plant and number of secondary branches per plant, respectively. The estimated GCA effects for total number of pods per plant and number of mature pods per plant were the highest in CG (24)-1-1-1 and Binachinabadam-4 while China Badam noticed the poorest GCA effect due to the highest significant negative GCA effects (Table 4). The parents China Badam was the best general combiner

Table 5. Specific combining ability effect for yield and yield attributing traits of cross combinations in a 4×4 diallel crossing experiment of groundnut.

Character / Crosses	DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
Binachinabadam-4 × Dacca-1	-1.40*	-0.14	-0.15	0.04	1.27*	1.00	0.05	2.89	2.92**	1.00	2.00*
Binachinabadam-4× GC (24)-1-1-1	0.90	1.41	-0.19	0.17	-0.94	-0.83	-0.06	-0.15	-4.56**	-5.34**	-0.01
Binachinabadam-4 × China Badam	0.27	1.59	0.15	-0.17	-3.56**	-2.29**	0.07*	-1.49	-0.58	0.64	-3.53*
Dacca-1 × GC (24)-1-1-1	-0.90	-3.55	0.31	0.25	-1.23*	1.04	0.14**	-0.97	-3.03**	-2.48*	-2.04*
Dacca-1 × China Badam	1.98**	0.81	-0.35	-0.08	-1.35*	-2.25**	-0.34**	-0.05	2.68**	4.91**	-1.63*
GC (24)-1-1-1 × China Badam	0.10	-3.02	1.4**	-0.46**	7.73**	7.58**	0.20**	22.78**	14.12**	2.36*	12.64**
SE (sij)	0.47	1.67	0.38	0.12	0.53	0.44	0.03	1.50	0.70	0.76	0.20

Note: * and ** indicates significant at 5% and 1% level of probability, respectively.
DM- days to maturity, PH- plant height (cm), PBP- primary branches per plant, SPB- secondary branches per plant, TPP- total pods per plant, MPP- mature pods per plant, NSP- number of seeds per pod, 100- pod weight, 100-seed weight, YPP- yield per plant.

due to the highest GCA effects for seeds per pod, 100-seed weight and shelling percentage whereas GC (24)-1-1-1 was the best general combiner due to the highest GCA effects for 100-pod weight, yield per plant.

According to SCA effect, the cross combination GC (24)-1-1-1 × China Badam showed the best specific combiner for maximum yield contributing characters such as primary branches per plant, total pods per plant, mature pods per plant, seeds per pod, 100-pod weight, 100-seed weight, yield per plant and shelling percentage (Table 5). Beside this, the plant height of this cross combinations showed a non-significant negative, the number of secondary branches per plant showed a significant negative and days to maturity showed a non-significant positive SCAs (Table. 5).

According to RCA effect, the cross combination China Badam × Binachinabadam-4 showed positive significant reciprocal effects for plant height, number of secondary branches per plant, number of total pods and mature pods per plant, shelling percentage and days to maturity (Table 6). In contrast, the cross combination China Badam × GC (24)-1-1-1 showed significant positive RCA effects for number of total and mature pods per plant, 100- seed weight and yield per plant; Dacca-1 × Binachinabadam-4 for 100-pod weight and 100-seed weight; GC (24)-1-1-1 × Binachinabadam-4 for shelling percentage, and China Badam × Dacca-1 for days to maturity (Table 6).

Heterosis for yield and yield attributing traits

The highest (3.39%) significant negative mid-parent heterosis for days to maturity was found the cross Dacca-1× Binachinabadam-4. Considering plant height, the highest (24.22%) significant positive heterosis was observed from the cross Binachinabadam-4× China Badam whereas the highest (-16.65%) significant negative heterosis was found from the cross GC (24)-1-1-1× Dacca-1. The cross China Badam × GC (24)-1-1-1 showed the highest (61.29%) significant positive heterosis for primary branches per plants whereas the highest (-12%) significant negative heterosis was found from the cross Binachinabadam-4 × Dacca-1. Similarly, the highest significant positive heterosis for total pods per plant (116%) and mature pods per plant (192.85%) was observed from the cross GC (24)-1-1-1 × China Badam whereas the highest significant negative heterosis was observed from the cross Dacca-1 × China Badam. The cross China Badam × Binachinabadam-4 showed the maximum positive heterosis (29.37%) for the trait seeds per pod. The cross combination GC (24)-1-1-1 × China

Table 6. Reciprocal combining ability effects for yield and yield contributing characters of cross combinations in a 4×4 diallel crossing experiment of groundnut.

Character / Crosses	DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
Dacca-1× Binachinabadam-4	1.17	1.98	-0.17	-0.17	-1.33	0.83	-0.01	8.24**	4.38**	-0.54	0.45
GC (24)-1-1-1× Binachinabadam-4	-0.33	-3.33	-0.50	0.17	-8.33**	-5.00**	-0.70**	-10.85**	0.96	9.7**	-9.16**
China Badam× Binachinabadam-4	2.64**	6.56*	-0.83	0.67**	1.67*	1.50*	-0.53**	-12.88**	-6.41**	3.23*	-0.62*
GC (24)-1-1-1× Dacca-1	0.67	0.67	0.50	0.14	1.00	1.83*	-0.19**	-1.10	-0.75	-0.14	0.36
China Badam × Dacca-1	1.50*	-1.28	-0.17	-0.17	-4.50**	-4.17**	-0.04	4.23	-1.20	-5.32**	-2.95**
China Badam × GC (24)-1-1-1	0.83	3.62	-0.17	-0.33	7.00**	5.00**	-0.08	3.63	2.79*	0.34	9.03**
SE (rij)	0.59	2.10	0.49	0.16	0.67	0.56	0.05	1.89	0.89	0.95	0.25

Note: * and ** indicates significant at 5% and 1% level of probability, respectively.
DM-days to maturity, PH- plant height (cm), PBP- primary branches plant, SPB- secondary branches plant, TPP- total pods plant, MPP- mature pods plant, NSP- number of seeds pod, 100- pod weight, 100- seed weight, YPP- yield plant.

Badam showed the highest significant positive heterosis (68.65 and 56%, respectively) for 100-pod weight and 100-seed weight. In case of yield per plant, the highest (261.56%) significant positive heterosis was found from the cross GC (24)-1-1-1 × China Badam. Importantly, its reciprocal cross also showed significant positive heterosis (107.05%) for yield per plant. Significant negative heterosis (-27.9*) was observed in the cross combination Binachinabadam-4×GC (24)-1-1-1. Considering the most of the studied traits the cross combination GC (24)-1-1-1 × China Badam showed maximum positive heterosis for yield and yield attributing traits (Table 7).

DISCUSSION

The knowledge on combining ability and type of gene action responsible for the regulation of expression of different traits would certainly help breeder to select the best parents for hybridization and identify potential hybrid lines with next breeding approach. Similarly, diallel cross has been extensively used for analysis of GCA, SCA, RCA and heterosis. In the present study, a 4 ×4 full diallel crossing experiment have been conducted to study the combining ability for yield and yield attributes. Significant genotypic variation was observed among the parents and hybrids for yield and yield attributing traits. Similar genotypic variation for yield and yield attributing traits were also reported by others in groundnut [12-14,19].

Variability in yield and yield attributing traits in parents and hybrids

Development of an early mature variety is one of the most important breeding strategies to fit it in the existing cropping pattern or to increase the cropping intensity. From the present study, the parent China Badam was found to mature earlier (required 130 days); however, it showed a non-significant difference with the hybrids obtained from the crosses GC (24)-1-1-1 × Dacca-1 and China Badam × GC (24)-1-1-1 (Table 2).

Binachinabadam-4 was the late maturing genotype as the genotype required maximum days (138 days) to mature. Although, the range of variation for days to maturity was not so high (130-138 days) among the parents and hybrids however they are statistically significant. Similar to our results, Sibhatu et al. [20] also reported that day to maturity ranges from 101-129 days while evaluating few genotypes of groundnut. However, Naeem-Ud-Din et al. [21] reported that the high yielding groundnut variety 'Golden' required 165-175 days for maturing.

Among the studied parents and hybrids, the highest plant height was observed for the parents GC (24)-1-1-1 and Daaca-1 had (49.56 and 49.30 cm, respectively) which did not differ significantly from most of the hybrids obtained

Table 7. Percentage of heterosis for yield and yield contributing traits in a 4 × 4 diallel crossing experiment of groundnut

Character Crosses	DM	PH (cm)	PBP	SBP	TPP	MPP	NSP	100-PW (g)	100-SW (g)	Shelling (%)	YPP (g)
Binachinabadam-4 × Dacca-1	-0.37	4.10	-12.00*	1.11	-11.11	4.17	-0.69	21.07**	3.25*	0.61	4.5
Binachinabadam-4 × GC (24)-1-1-1	0.37	-6.84	2.32	33.33	-31.17*	-18.75	4.94	0.71	-3.03	-3.48	-27.9*
Binachinabadam-4 × China Badam	2.99*	24.22*	-3.23	7.69	-11.54	-2.50	-17.22	-4.88	0.05	5.39*	-12.66
Dacca-1 × Binachinabadam-4	-2.07*	-4.76	-4.00	33.33	1.58	-6.250	0.86	-6.28	-4.72	2.523	-3.57
Dacca-1 × GC (24)-1-1-1	-0.24	-13.95*	36.00**	33.33	9.83	55.55*	4.48	14.65*	1.89	-9.71*	18.69*
Dacca-1 × China Badam	3.39*	-5.21	2.13	-23.07	-41.66**	-53.57*	-18.20	24.30**	32.13**	5.10*	-26.84*
GC (24)-1-1-1× Binachinabadam-4	0.86	8.024*	25.00*	1.65	33.76**	43.75*	12.38	33.98**	-7.10	-30.45**	80.30*
GC (24)-1-1-1 × Dacca-1	-1.24*	-16.65*	12.00	33.33	2.34	25.00	23.06**	17.99*	5.49	-9.24	16.35
GC (24)-1-1-1 × China Badam	1.64*	-5.353	48.38**	-53.84	116.0**	192.85 **	22.09**	68.65**	56.00**	7.58*	261.56**
China Badam × Binachinabadam-4	-0.99	-10.10*	29.03*	-53.84	-30.76*	-25.00	29.37**	35.48**	29.69**	-4.17*	-2.25
China Badam × Dacca-1	1.13	0.778	6.25	-7.69	33.33*	35.71	-14.95	11.21	41.54**	23.76**	54.07*
China Badam × GC (24)-1-1-1	0.38	- 22.18**	61.29**	-23.07	32.00*	85.71**	28.53**	58.25**	44.97**	-8.53*	107.05**

Note: *and ** indicates significant at 5% and 1% level of probability, respectively.
DM- days to maturity, PH- plant height (cm), PBP- primary branches per plant, SPB- secondary branches per plant, TPP- total pods per plant, MPP- mature pods per plant, NSP- number of seeds per pod, 100- pod weight, 100- seed weight, YPP- yield per plant.

from eight cross combinations (Table 2). In contrast, the parents China Badam and the cross combination, China Badam × GC (24)-1-1-1 had the lowest plant height (36.36 and 33.43 cm, respectively). Similar to our results, the high yielding groundnut verity 'Golden' showed a plant height of 32.5cm [21]. Yol et al. [22] reported that plant height of *Arachis hypogaea* species ranges from 34.2-72.9 cm while studying a huge germplasm of groundnut in the Mediterranean Basin. However, the plants that have short plant stature usually requires few days for flowering and accumulation of the maximum numbers of early flowers is an important trait to develop short duration groundnut cultivars [23].

Branching is one of most important traits and groundnut and for seed yield [24-25]. In the present study, the highest number (6.33) of primary branches per plant was produced by the genotype China Badam however it showed a non-significant differences with the hybrids obtained from the cross China Badam × GC (24)-1-1-1 and the cross combination GC (24)-1-1-1 × China Badam. Similarly, the highest number of secondary branches produced by the parent China Badam and the hybrids obtained from the cross Binachinabadam-4 × China Badam and China Badam × Dacca-1(Table 2). Similar number of primary and secondary branches per plant was also reported in groundnut [22, 26].

The genotypes having higher number of pods per plant offer an opportunity for improving seed yield per plant in groundnut [22, 27-28]. Therefore, the number of total pods and mature pods per plant is one of the selection criteria to obtain higher seed yield in groundnut breeding. In the present study, significant differences were observed among the parents and hybrids considering these traits. The trait also had significant differences among genotypes in the collection in accordance with Swamy et al. [29] and Upadhyaya et al. [30]. Among the parents, maximum number of total pods per plant and total pods per plant was found in Binachinabadam-4 which ranges from 8.33-26.33 and 6.66-20. Among the hybrids highest number of pods per plant was recorded in the cross GC (24)-1-1-1 × China Badam. Our results of pods per plant and total pods per plant are in accordance with the results of others [22, 26].

In respect of number of seeds per pod, the cross China Badam × GC (24)-1-1-1 had more than three seeds which showed a non-significant difference with the hybrids obtained from the cross China Badam × Binachinabadam-4 and GC (24)-1-1-1 × China Badam (Table 2). Among the parents, China Badam showed the highest number (2.59) of seeds per pod. Significant variability in number of seeds per pod in groundnut was also reported by others [20-21].

Significant variability was also observed among the parents and hybrids for the traits 100-pod weight and 100-seed weight. The highest 100-pod weight and 100-seed weight was found in the F_1 hybrid obtained from the cross GC (24)-1-1-1 × China Badam and its reciprocal hybrids. Pod weight ranges from 56.48 to 117.40 g whereas 100-seed weight ranges from 28.28-78.83 g respectively (Table 2). Similar ranges of 100-pod yield and 100-seed yield were also reported in groundnut [20, 30-31].

Shelling percentage is an index of the percentage of grains or seeds [32] and is one of the important selection criteria in groundnut breeding [33]. Significant variation in parents and hybrids were observed due to shelling percentage. The highest shelling percentage was found in the parent Binachinabadam-4 whereas the cross combination Dacca-1 × GC (24)-1-1-1 had the highest shelling percentage (72.21%) and the. The lowest shelling percentage (45.07%) was observed from the cross between the cross Binachinabadam-4 × Dacca-1(Table 2). Similar results of shelling % in parents and hybrids in groundnut were also reported by others [22, 26, 31].

Obtaining higher seed yield for different environmental conditions is one of the most important challenges in plant breeding. Significant variation was found for yield per plant among the studied parents and hybrids (Table 2). The highest, yield per plant was found in the parent Binachinabadam-4 however F_1 hybrid produced from the cross GC (24)-1-1-1 × China Badam and its reciprocal hybrid showed the highest yield per plant (42.52 and 38.80 g, respectively). The cross combination Dacca-1 × China Badam had the lowest yield per plant (5.56 g) among the crosses and parents. Significant variation in yield per plant among parents and hybrids were also reported by others [26].

Combining ability for yield and yield attributes

Analysis of variance of combining ability of the yield and yield attributing traits (days to maturity, plant height and primary branch per plant, total pods per plant, mature pods per plant, seeds per pod, 100-pod weight, 100-seed weight, shelling percentage and yield per plant showed high significant GCA and SCA mean square which indicates that both additive and non-additive gene effect on these traits (Table 3). Similar to our results, multiple gene action responsible for these traits was also reported by Kamdar et al. [34]. The significant RCA variance also indicates the influence of maternal effect in controlling the traits. Similar reciprocal effects were also reported in groundnut by other researchers [31, 35]. The variances due to dominance deviation (V_D) for yield and yield attributing traits were much higher than the additive deviation (V_A) suggested predominance of non-additive gene action for the inheritance of these traits. The involvement of both additive and non-additive gene action for yield and yield attributing traits has been reported by others [1, 11-12, 14, 19, 35-37]. Few researchers were also recorded only additive gene effect on trait controlling in groundnut [38-39]. The discrepancy in results may be due to the differences of genetic material and environmental conditions in which experiment was conducted. The hybrids obtained from the cross combination GC (24)-1-1-1 × China Badam exhibited high positive SCA effects most of the studied traits (Table 5). Additionally, the highly significant GCA effects shown by GC (24)-1-1-1 and China Badam further justifies these genotypes as an important donor parent for enhancing the yield and yield contributing traits (Table 4). The cross combination China Badam × GC (24)-1-1-1 had significant positive reciprocal effect suggesting that the reverse cross in superior in terms yield and yield attributing traits suggesting the suitability of GC (24)-1-1-1 parent as both male and female parent (Table 6). Similar results were also reported in groundnut while studying the combining ability [12-13]. Favorable SCA estimates and involving one parent with high GCA would likely enhance the concentration of favorable alleles to improve target traits [38, 40].

Heterosis for yield and yield attributes

Utilization of heterosis has become a major strategy for increasing productivity of plants. Heterosis study helps to find out the hybrids which have higher economical potential. In present study, heterosis was recorded over mid parent of these genotypes. The result of heterosis revealed that the most of the new hybrid lines are more superior yielder than their respective mid-parents (Table 7). Significant positive heterosis is desirable for primary branches per plant, secondary branches per plant, total pods per plant, mature pods per plant, seeds per pod, 100-pod weight, 100-seed weight, shelling percentage and yield per plant but significant negative heterosis is desirable for days to maturity and plant height. The hybrids obtained from the cross Dacca-1 × Binachinabadam-4 and GC (24)-1-1-1 × Dacca-1 showed negative heterosis for days to maturity indicates earliness. Similarly, hybrid obtained from the cross China Badam × GC (24)-1-1-1 showed high negative heterosis for plant height. These results are in accordance with the results of others [41-42]. Significant positive heterosis for yield and yield attributing traits was also observed from different cross combinations such as China Badam × GC (24)-1-1-1 for number for primary branches, GC (24)-1-1-1 × China Badam for mature pods per plant, China Badam × Binachinabadam-4 and China Badam × GC (24)-1-1-1 for seed per pod, GC (24)-1-1-1 × China Badam for100-pod weight and 100-seed weight, China Badam × Dacca-1 for shelling percentage. A similar positive result of heterosis for yield related traits were also reported by others [41, 43]. The most important trait yield per plant showed both positive and negative heterosis values among these hybrids. The hybrid GC (24)-1-1-1 × China Badam and its reciprocal hybrid China Badam × GC (24)-1-1-1 showed highest mid-parent heterosis for yield per plant. Significant positive heterosis for yield was also reported by others [44-46]. As these cross combinations exhibited higher superiority over mid-parent so, they could be used in isolating potential lines and explore to break yield barrier with desirable groundnut production.

CONCLUSION

Analysis of diallel cross involving four parents indicated that the parent GC (24)-1-1-1 and China Badam were found as best general combiner. Best SCA performance were reported for pods per plant, seeds per plant, 100-pod weight, 100-seed weight, shelling percentage and yield per plant in the hybrid obtained from the cross GC (24)-1-1-1 × China Badam. The RCA also suggested that the cross combination China Badam × GC (24)-1-1-1 has potential to increase these yield performances. So, the combination GC (24)-1-1-1 × China Badam and China Badam × GC (24)-1-1-1 were identified as promising combinations. Significant heterosis was also observed in these cross combinations for yield and yield attributing traits. As the expression of majority of the traits in groundnut is regulated by both additive and non-additive gene action so, selection in later generation would be more effective in developing new varieties for high yielding and large seeded groundnut variety.

ACKNOWLEDGEMENTS

Authors gratefully acknowledge the financial support provided by Ministry of Agriculture, Government of the People's Republic of Bangladesh.

REFERENCES

[1] Alam, M. K., Nath, U. K., Azad, M. A. K., Alam, M. A. and Khan, A. A. 2013. Combining ability analysis for yield and yield contributing traits of groundnut. J Sci Tech, 11: 106-111.

[2] Janila, P., Nigam, S.N., Pandey, M.K., Nagesh, P. and Varshney, R.K. 2013. Groundnut improvement: Use of genetic and genomic tools. Front Plant Sci, 2013: 4.

[3] Janila, P., Variath, M.T., Pandey, M.K., Desmae, H., Motagi, B.N., Okori, P., Manohar, S.S., Rathnakumar, A.L., Radhakrishnan, T., Liao, B. and Varshney, R.K. 2016. Genomic tools in groundnut breeding program: status and perspectives. Front Plant Sci, 7: 289.

[4] Miah, M. A. M. and Mondal, M. R. I. 2017. Oilseeds sector of Bangladesh: challenges and opportunities. SAARC J Agric, 15(1): 161-172.

[5] BBS, 2019, Bangladesh Bureau of Statistics, Agricultural Statistical Year book of Bangladesh, Dhaka, Bangladesh.

[6] Hamid, M.A., Azad, M.A.K. and Howelider, M.A.R. 2006. Development of three groundnut varieties with improved quantitative and qualitative traits through induced mutation. Plant Mut Rep, 1(2): 14-16

[7] Lambeth, C., Lee, B.C., O"Malleya, D. and Wheeler, N. 2001. Polymix breeding with parental analysis of progeny: an alternative to fullsib breeding and testing. Theor Appl Genet, 103:930–943.

[8] Huang, M., Chen, L.Y. and Chen, Z.Q. 2015. Diallel analysis of combining ability and heterosis for yield and yield components in rice by using positive loci. Euphytica, 205: 37–50.

[9] Asfaliza, R., Rafii, M.Y., Saleh, G., Omar, O. and Puteh, A. 2012. Combining ability and heritability of selected rice varieties for grain quality traits. Aust J Crop Sci, 6: 1718–1723.

[10] Fasahat, P., Rajabi, A., Rad, J.M. and Derera, J. 2016. Principles and utilization of combining ability in plant breeding. Biomet Biostat Int J, 4: 00085

[11] Boraiah, K. M., Goud, I. S., Gejli, K., Somasekar, C. K. and Vetriventhan, M. 2014. Combining ability and gene action for yield and yield contributing traits in groundnut (*Arachis hypogaea* L.). Legume Res, 39 (1): 1-5.

[12] Hariprasanna, K., Lal, C., Radhakrishnan, T., Gor, H. K. and Chikani, B. M. 2008. Analysis of diallel cross for some physical-quality traits in peanut (*Arachis hypogaea* L.). Euphytica, 160(1):49-57.

[13] Azad, M., Kalam, A., Hamid, M., Rafii, M. Y. and Malek, M. A. 2014. Combining ability of pod yield and related traits of groundnut (*Arachis hypogaea* L.) under salinity stress. The Sci World J, 2014: Article ID 589586.

[14] Khute, A.K., Rao, S.S., Painkra, O. and Markam, N. 2018. Combining ability for yield and yield components in groundnut (*Arachis hypogaea* L.). Int J Curr Microbiol App Sci, 7(2): 2798-2804.

[15] Amoah, A.R., Akromah, R., Asibuo, J.Y., Wireko-Kena, A., Asare, K. B. and Lamptey, M. 2020. Mode of inheritance and combining ability of oleic acid content in groundnut (*Arachis hypogaea* L.). Ecol Genet Genom, 17:100064

[16] Sales, N., Bartolome, V., Caneda, A., Gulles, A., Morantte, R.I.Z., Nora, L., Raquel, A.M., Relente, C.E., Talay, D. and Ye, G. 2013. PB Tools software for Plant Breeding. International Rice Research Institute, College, Losbanon, Laguna, Philippines.

[17] Griffing, B. 1956. Concept of general and specific combining ability in relation to diallel crossing systems. Aust J Biol Sci, 9(4): 463-493.

[18] Rai, B. 1979. Heterosis Breeding. Agro-biological Publication, Delhi, India. pp.183.

[19] Nath, U.K., Azad, M.A.K., Alam, M.A. and Khan, A.A. 2013. Genetics of yield and related traits in groundnut using diallel analysis. Bull Inst Trop Agri Kyushu Uni, 36(1): 045-059.

[20] Sibhatu, B., Harfe, M. and Tekle, G. 2017. Groundnut (*Arachis hypogaea L.*) varieties evaluation for yield and yield components at Tanqua-Abergelle district, Northern Ethiopia. Sky J Agric Res, 6(3): 057- 061.

[21] Naeem-Ud-Din, Mahmood, A., Khattak, G.S.S., Saeed, I. and Hassan, M.F. 2009. High yielding groundnut (*Arachis hypogea* L.), variety "golden". Pak J Bot, 41(5): 2217-2222.

[22] Yol, E., Furat, S., Upadhyaya, H.D. and Uzun, B. 2018. Characterization of groundnut (*Arachis hypogaea* L.) collection using quantitative and qualitative traits in the Mediterranean Basin. J Integr Agric, 17(1): 63–75

[23] Nigam, S.N. and Aruna, R. 2008. Improving breeding efficiency for early maturity in peanut. Plant Breed Rev, 30: 295–322.

[24] Rehman, A.U., Wells, R., Isleib and T.G. 2001. Reproductive allocation on branches of virginia-type peanut cultivars bred for yield in North Carolina. Crop Sci, 41: 72–77.

[25] Kumar, S.I., Govindaraj, M. and Kumar, V.K. 2010. Estimation of genetic diversity of new advanced breeding lines of groundnut (*Arachis hypogaea* L.). World J Agric Sci, 6:547–554.

[26] Rahmianna, A.A., Wijanarko, A., Purnomo, J. and Baliadi, Y. 2020. Yield performance of several peanut cultivars grown in dryland with semi-arid climate in Sumba Timur, Indonesia. Biodiversitas, 21 (12): 5747-5757

[27] Nath UK and Alam MS. 2002. Genetic variability, heritability and genetic advance of yield and related traits of groundnut (*Arachis hypogaea* L.). J Biol Sci, 2: 762–764.

[28] Luz, L. N., Santos, R. C. and Filho, P. A. M. 2011. Correlations and path analysis of peanut traits associated with the peg. Crop Breed App Biotechnol, 11: 88–93.

[29] Swamy, B.P.M., Upadhyaya, H.D., Goudar, P.V.K., Kullaiswamy, B.Y. and Singh, S. 2003. Phenotypic variation for agronomic characteristics in a groundnut core collection for Asia. Field Crops Res, 84: 359–371.

[30] Upadhyaya, H.D., Reddy, L.J., Gowda, C.L.L. and Singh, S. 2006. Identification of diverse groundnut germplasm: Sources of early-maturity in a core collection. Field Crop Res, 97: 261–267.

[31] Nayak, P.G., Venkataiah and Revathi, P. 2020. Combining Ability and Heterosis Studies for Yield and Yield Contributing Characters in Groundnut (*Arachis hypogaea* L.). Curr J Appl Sci Technol, 39(48): 566-573

[32] Dapaah, H., K., Mohammed, I. and Awuah, R. T. 2014. Growth and yield performance of groundnuts (*Arachis hypogaea* L.) in response to plant density. Int J Plant Soil Sci, 3: 1069–1082.

[33] Anothai, J., Patanothai, A., Jogloy, S., Pannangpetch, K., Boote, K. J. and Hoogenboom, G., 2008. A sequential approach for determining the cultivar coefficients of

peanut lines using end-of-season data of crop performance trials. Field Crop Res, 108:169–178.

[34] Kamdar, J. H., Jasani, M. D., Bera, S. K. and Georrge, J. J. 2020. Effect of selection response for yield related traits in early and later generations of groundnut (*Arachis hypogaea* L.). Crop Breed Appl Biotechnol, 20: e317320215.

[35] Neya, F.B., Sanon, E., Koita, K., Zagre, B.M.B. and Sankara, P. 2017. Diallel analysis of pod yield and 100 seeds weight in peanut (*Arachis hypogaea* L.) using GRIFFING and HAYMAN methods. J Appl Biosci, 116:11619-11627.

[36] Pramesh, Kh., Chanu, H. P. and Sharma, P. R. 2017. General and specific combining ability analysis for yield and yield contributing characters in groundnut (*Arachis hypogaea* L.). Electron J Plant Breed, 8(3):973-979.

[37] Reddy, A. T., Sekhar, M. R., Vijayabharathi, A., Pathy, T. L., Reddy, G. L. and Jayalakshmi, V. 2017. Studies on combining ability and heterosis for yield and its component traits in groundnut (*Arachis hypogaea* L.). Int J Cur Microbiol App Sci, 6(12): 551-559.

[38] Zongo A., Nana, A. T., Sawadogo, M., Konate, A.K., Sankara, P., Ntare, B.R. and Desmae, H. 2017. Variability and correlations among groundnut populations for early leaf spot, pod yield, and agronomic traits. Agronomy, 7(3): 52

[39] Oppong-Sekyere, D., Akromah, R., Ozias-Akins, P. and Laary, J. K., Gimode, D. 2019. Heritability studies of drought tolerance in groundnuts using the North Carolina design II fashion and variance component method. J Plant Breed Crop Sci, 11(9): 234-253.

[40] Kenga, R., Alabi, S.O. and Gupta, S.C. 2004. Combining ability studies in tropical sorghum (*Sorghum bicolor* (L.) Moench). Field Crop Res, 88 (2–3): 251–260.

[41] Boraiah, K. M., Goud, S., Gejli, K., Konda, C. R. and Babu, H. P. 2012. Heterosis for yield and yield attributing traits in groundnut (*Arachis hypogaea* L.). Legume Res: An Int J, 35(2):119-125.

[42] Prahalada G.D and Boraiah K.M. 2010. Estimation of heterosis for yield and yield attributing traits in groundnut (*Arachis hypogaea* L.). DOI:10.13140/2.1.3890.6245.

[43] Gor, H.K., Dhaduk, L.K. and Lata, R. 2012. Heterosis and inbreeding depression for pod yield and its components in groundnut (*Arachis hypogaea* L.). Electron J Plant Breed, 3(3): 868-874.

[44] John, K. and Reddy, R.P. 2014. Combining ability and heterosis for yield and water use efficiency traits in groundnut. Legume Res - An Int J, 373: 235-244.

[45] Patil, S., Shivanna, S., Irappa, B. M. and Shweta. 2015. Genetic variability and character association studies for yield and yield attributing components in groundnut (*Arachis hypogaea* L.). Int J Recent Sci Res, 6(6): 4568-4570.

[46] Waghmode, B.D., Kore, A. B., Navhale, V.C., Sonone, N.G. and Bhave, S.G. 2017. Heterosis for pod yield and its component traits in groundnut (*Arachis hypogaea* L.). Electron J Plant Breed, 8: 1140-1147.

.

تجزیه و تحلیل قابلیت ترکیب پذیری و هتروزیس عملکرد و صفات مرتبط با عملکرد در بادام زمینی (*Arachis hypogaea* L.) با استفاده از روش تلاقی دای الل

ریحان سیکدر[1,2]، ابوالکلام آزاد[2] و محمدانور حسین [1*]

[1] گروه ژنتیک و اصلاح نباتات، دانشکده کشاورزی، دانشگاه کشاورزی بنگلادش، میمنسینگ، بنگلادش

[2] موسسه کشاورزی هسته‌ای بنگلادش، میمنسینگ، بنگلادش

*نویسنده مسئول: anwargpb@bau.edu.bd

چکیده

بادام‌زمینی (*Arachis hypogaea* L.) یکی از دانه‌های روغنی مهم در جهان است که منبع مهم پروتئین در بسیاری از کشورها محسوب می‌شود. برای بررسی ماهیت قابلیت ترکیب‌پذیری و هتروزیس صفات عملکرد و اجزای عملکرد، یک آزمایش دای آلل کامل ۴ × ۴ در قطعه آزمایشی موسسه کشاورزی هسته‌ای بنگلادش، واقع در میمنسینگ - بنگلادش انجام و صفات مربوطه ثبت شد. تجزیه وتحلیل داده‌ها نشان داد که تفاوت معنی‌داری بین والدین و هیبریدها از نظر عملکرد و صفات مربوطه وجود دارد. تجزیه واریانس ترکیب‌پذیری عمومی (GCA)، خصوصی (SCA) و متقابل نیز تغییرات معنی‌داری را برای تمامی صفات مورد مطالعه نشان داد. نتایج ترکیب پذیری عمومی و خصوصی حاکی از وجود هر دو اثر افزایشی و غیر افزایشی در کنترل صفات مورد مطالعه بود. تاثیرات چشمگیر اثر غیرافزایشی ژن‌ها نشان می‌دهد که انتخاب در نسل‌های پیشرفته بسیار موثر می‌باشد. معنی‌داری اثرات متقابل برای همه صفات نشان دهنده نقش اثرات مادری در بروز این صفات است. ژنوتیپ‌های GC (24)-1-1-1 و China Badam می‌توانند والدین مناسبی در تلاقی برای بهبود صفات تعداد دانه در غلاف، وزن ۱۰۰ غلاف، وزن ۱۰۰ دانه، درصد پوست و عملکرد در بوته باشند. نتایج مقایسه میانگین‌ها و ترکیب پذیری خصوصی نشان داد که ژنوتیپ‌ها قابلیت لازم در انتقال این صفات کمی مهم را دارند. تجزیه وتحلیل ترکیب پذیری خصوصی و هتروزیس نشان داد که در بین F1های حاصل از تلاقی‌ها ترکیب GC (24)-1-1-1 × China Badam برای بسیاری از صفات مناسب بوده و از آن می‌توان برای انتخاب ژنوتیپ‌های با صفات مطلوب در طی نسل‌های در حال تفرق جهت به حداکثر رساندن علمکرد استفاده کرد.

کلمات کلیدی: *Arachis hypogaea*، تلاقی دای آلل، والدین، هیبریدها، اثر ژن و بهبود عملکرد