HALF DIALLEL ANALYSIS FOR F_3 GENERATION OF PEA *(Pisum sativum L.)* UNDER SULAIMANI CONDITION-IRAQ KURDISTAN REGION

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ABSTRACT

This study was carried out at Qlyasan location in Sulaimani region (Lat 35 º 34' 307''; N, long 45º 21' 992; E, 765 masl) for F_3 generation of seven pea varieties (1-Avolla, 2-Americana, 3-Jeza, 4-Joneor, 5-Packland, 6-Arvena and 7-Samara). The seeds of 21 F_3 crosses and their parents were sown in Completely Randomized Block Design (CRBD).With three replicates. The results showed that the mean squares of genotypes, gca and sca were highly significant for seed weight plant^{-1} and most its important components. The parents Americana and Jeza recorded maximum values for all studied characters. The cross AvollaxAmericana recorded the highest value for seed weight plant^{-1} and pod weight plant^{-1}. The cross AvollaxPackland had the highest value for heterosis due to seed weight plant^{-1} 122.114% and whole plant weight 147.111%. The parent Americana recorded maximum positive gca effect value for seed weight plant^{-1} and some its components pod length, pod weight plant^{-1} and 100-seed weight. The crosses JezaxArvena recorded maximum positive sca effect value for seed weight plant^{-1}, while the cross AvollaxArvena showed maximum positive sca effect value for pod length and pod plant^{-1}. The average degree of dominance was more than one for all characters indicating to the importance of non additive gene effect in controlling the inheritance of these characters. Heritability in broad sense was high for seed weight plant^{-1} and some its components pods number plant^{-1}, pod weight plant^{-1} and 100-seed weight, while it was low in narrow sense for all characters.

Key word: gca, sca, genotypes, heterosis, heritability

مجلة العلوم الزراعية العراقية -2020: 51 (3):848-855 توفيق و آخرون

تحليل التضريب التبادلي النصفي للجيل الثالث F_3 للبازلاء (*Pisum sativum* L.) تحت ظروف منطقة السليمانية، اقليم كوردستان العراق

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المستخلص

أجريت هذه الدراسة في محطة قلياسان للبحوث الزراعية في منطقة السليمانية للجيل الثالث F_3 من سبعة أصناف من البازلاء Avolla, Americana, Jeza, Joneor, Packland, Arvena and Samara). زرعت بذور هذه الهجن 21 F_3 مع آبائهم في تصميم القطاعات الكاملة (CRBD) المقاسة بثلاث مكررات. أظهرت النتائج أن متوسط المربعات للتراكيب الوراثية gca , sca كانت عالية المعنوية بالنسبة لوزن البذور نبات$^{-1}$ ومعظم مكوناته الهامة. سجل الآباء Americana وJeza أعلى القيم لجميع الصفات المدروسة. سجل الهجين AvollaxAmericana أعلى قيمة لوزن البذورنبات$^{-1}$ و وزن القرنات نبات$^{-1}$. أنتج الهجين AvollaxPackland أعلى قيمة لقوة الهجين لوزن البذورنبات$^{-1}$ 122.114٪ والوزن الكلي نبات$^{-1}$ 147.111٪. سجل الصنف Americana القيمة القصوى لتأثير gca الموجب لوزن البذورنبات$^{-1}$ و بعض مكوناتها مثل طول القرنة ، وزن القرنات نبات$^{-1}$ ووزن 100-بذرة. سجل الهجين JezaxArvenaأعلى قيمة موجبة لتأثير sca لوزن البذور نبات$^{-1}$, بينما أظهر الهجين AvollaxArvena أعلى قيمة موجبة لتأثير scaلطول القرنة و عدد القرنات نبات$^{-1}$. كانت معدل درجة السيادة أكثر من الواحد لجميع الصفات مما يدل على أهمية تأثير الفعل الجيني غير المضيف في السيطرة على هذه الصفات. كانت درجة التوريث في معناها العام عالية بالنسبة لوزن البذور نبات$^{-1}$ وبعض مكوناتها مثل عدد القرنات نبات$^{-1}$، وزن القرنات نبات$^{-1}$ و وزن-100 بذرة، في حين كانت واطئة بالمعنى الضيق لجميع الصفات المدروسة.

كلمات مفتاحية: قابلية التآلف العامة و الخاصة، هجين البزاليا، قوة الهجين، درجة التوريث.

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INTRODUCTION

Garden pea (*Pisum sativum var. hortense* L.), belongs to leguminosae family, is one of the most popular vegetable crop grown all over the world, both for fresh market and the food processing industry. It has a prominent place among vegetables due to its high nutritive value, particularly proteins and other health building substances like carbohydrates vitamin A, vitamin C, calcium and phosphorus (14). Sharma *et al*., (15) carried out combining ability analysis from diallel cross of pea cultivars and found that gca variance were significant for all characters except pod breadth for which sca variance was higher. The *per se* performance of parents and crosses was usually associated with the combining ability effects. Singh *et al*., (18) derived information on combining ability in garden pea involving twenty one crosses and seven parents. The gca and sca variances were highly significant for all the traits (days to flowering, pods number plant^{-1} and pod length). The sca variances were predominant in comparisons to gca variances for all the characters that indicated the greater contribution of non-additive gene action in the expression of these characters (10). Diallel cross and its analysis are considered to be one of the important program attained by breeding scientists for early generation testing of possible crosses between genotypes that produces the best crosses assigning from combined parent, then to introduce them in a breeding program to obtain new varieties and hybrids (4). The knowledge of gene action is very useful to a plant breeder in the selection of parents for hybridization, the estimation of some other genetic parameters and choice of breeding procedures for the genetic improvement of various quantitative characters. In an autogamous crop exploitation of non-additive genetic variance as such would be impractical. Genes are the functional units that govern the development of various characters of an individual. Gene action refers to the behavior or mode of expression of genes in a genetic population. Genes control synthesis of proteins which in turn control expression of various traits of organisms. Knowledge of gene action in plant breeding helps in the selection of parents for use in the hybridization programmers and also in the choice of appropriate breeding procedure for the genetics improvement of various quantitative characters. Klence insight into the nature of gene action involved in the expression of various quantitative characters is essential to a plant breeder for starting a judicious breeding program (16). Dominant alleles were more frequent in parental lines for the inheritance of most of the characters. Low to medium narrow sense heritability indicated presence of non-additive gene action for most of the traits except for pod yield (21). Dhillon *et al*., (8) reported additive and non-additive gene effects governed the inheritance of all the studied characters. The additive gene effects were more pronounced for days to flower initiation; pods number plant^{-1} and pod length, whereas the non-additive gene effects were more pronounced for seeds number pod^{-1}, dry matter content and total green pod yield plant^{-1}. Sharma and Bora, (16) reported higher values of heritability in broad sense and genetic gain indicating that the additive gene actions are important in determining the characters green pod yield and days to 50% flowering revealed. Therefore, selection program based on these characters would be more effective in improving yield parameters of garden pea. Combining ability analysis for six physiological characters in pea revealed leaf area and chlorophyll-a/b ratio was governed by additive gene action, while both additive and non-additive gene actions were important for controlling some traits as found by (20). This study was aimed to estimate general and specific combining ability values for yield related traits among seven pea varieties and to identify appropriate parents and F_3 crosses for the traits evaluated to assess their potential use in pea breeding programs.

MATERIALS AND METHODS

This study was conducted at Qlyasan Agricultural Research Station, College of Agricultural Engineering Sciences, University of Sulaimani (Lat 35 º 34' 307"; N, long 45º 21' 992; E, 765 masl), 2km North West of Sulaimani city. Seven field pea varieties (Avolla, Americana, Jeza, Joneor, Pack land, Arvena and Samara) were crossed in half diallel mating design without reciprocals. Seed of the F_3 crosses with parental lines were sown in Randomized complete Block Design (RCBD) with three replications. Each plots consisted of 21 F_3 and their parents (Table 1) on single 3m row with 0.4m row spacing and within the row 0.3m. Field management, fertilization and weed control were accomplished according to normal Field practice. At maturity, harvesting was accomplished by hands.

Evaluated characters: Data of agronomic traits were recorded from five plants of each genotype from each replication:

1- Days number to 50% flowering: The number of days to 50% flowering was recorded

2- Whole plant weight (g) :The weight of five plants was average and recorded.

3- Pod length (cm): The length of five pods was average and recorded.

4- Seeds no. pod^{-1} :The number of seeds per five pods was counted and average was recorded as seeds number pod^{-1}.

5- Pods no. plant^{-1} :The number of pod per five plants was counted and average was recorded as pods number plant^{-1}.

6- Pod weight plant^{-1} (g) :The weight of pods of five plants was average and recorded.

7- Seed weight pod^{-1}(g): The weight of seed pods^{-1} of five plants average and recorded.

8- 100-seed weight (g); ed were accounted and weight and recorded.

9- Seed weight plant^{-1} (g): The weight of seeds of five plants was weighted, average and recorded.

Genetic parameters:

1- General combining ability (gca)

2- Specific combining ability (sca)

3- Heterosis %

4- Heritability in Broad Sense

5- Heritability in narrow Sense

6- Average Degree of dominance (ā)

Table 1. Studied breeding materials

No.	Crosses, and parental no.	Parentage
1	1 × 2	Avolla × Americana
2	1 × 3	Avolla × Jeza
3	1 × 4	Avolla × Joneor
4	1 × 5	Avolla × Packland
5	1 × 6	Avolla × Arvena
6	1 × 7	Avolla × Samara
7	2 × 3	Americana × Jeza
8	2 × 4	Americana × Joneor
9	2 × 5	Americana × Packland
10	2 × 6	Americana × Arvena
11	2 × 7	Americana × Samara
12	3 × 4	Jeza × Joneor
13	3 × 5	Jeza × Packland
14	3 × 6	Jeza × Arvena
15	3 × 7	Jeza × Samara
16	4 × 5	Joneor × Packland
17	4 × 6	Joneor × Arvena
18	4 × 7	Joneor × Samara
19	5 × 6	Packland × Arvena
20	5 × 7	Packland × Samara
21	6 × 7	Arvena × Samara
22	1	Avolla
23	2	Americana
24	3	Jeza
25	4	Joneor
26	5	Packland
27	6	Arvena
28	7	Samara

RESULTS AND DISCUSSION

Results in Table 2 indicate to mean squares of genotypes, gca and sca for the studied characters, confirming the highly significant mean squares due to genotypes and gca for all characters except days number to 50% flowering, which was found to be significant only. The mean squares due to sca were highly significant for all characters, except the characters, day's number to 50% flowering and pod length, which not significant. Highly significant mean squares for genotypes confirmed the importance of splitting these mean squares to general and specific combining ability. Similar results reported perversely by (2, 3, 11, 22 and 24).

Table 2. Mean squares of variance analysis

S.O.V.	d.f	M.S Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	Pod weight plant^{-1} (g)	Seed weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
Blocks	2	81.721	7.429	0.052	0.114	8.650	12.855	0.051	3.866	9.063
Genotypes	27	141.857	16.474	2.449	2.508	27.021	41.265	0.117	34.922	23.178
gca	6	47.006	7.780	1.714	0.407	9.459	22.855	0.067	14.865	5.028
sca	21	47.365	4.838	0.560	0.210	8.878	11.155	0.031	10.719	8.497
Error	54	16.537	8.638	1.078	0.180	2.763	4.353	0.039	2.681	3.544
Mse´		5.512	2.879	0.359	0.060	0.921	1.451	0.013	0.894	1.181

Data represent in Table 3 reveal the means of the studied characters for the diallel crosses and their parents. The cross 1x2 recorded maximum values due to the characters pod weight plant^{-1} and seed weight plant^{-1} with 18.617 and 14.180 g respectively, and it was found to be the earlier cross recording 108.000 days to reach 50% flowering. Maximum value for whole plant weight and pods number plant^{-1} recorded by the cross 1x5 with 36.927g and 19.267 pods respectively the highest seed weight pod^{-1} was 1.537g recorded by the cross 1x6. The cross 2x4 produced the highest value for pod length seeds number pod^{-1} with 10.067cm and 5.900 seeds respectively the highest value due to 100-seed weight was 25.003g recorded by the cross 3x4. Regarding to the parental values, parent 1 recorded minimum days to reach 50% flowering with 114.667 days. Parent 2 recorded the highest value for the characters pod length, seed weight pod^{-1}, 100-seed weight and seed weight plant^{-1} reaching 8.500cm, 1.320g, 26.603g and 12.073g respectively, while parent 3 produced the highest for whole plant weight, pods number plant^{-1} and pod weight plant^{-1} with 28.537g, 5.200 pods and 16.630g. Maximum value due to seeds number pod^{-1} was 58.33 seeds recorded by parent 4. Different values among F_1 crosses and their parents were recorded perversely by (2 and 23) and F_2 crosses and their parents (3).

Table 3. Means of the studied characters for parents and their F_3 crosses

Crosses and parents	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	Pod weight plant^{-1} (g)	Seeds weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
1 x 2	32.510	108.000	7.467	5.103	13.733	18.617	1.125	24.423	14.180
1 x 3	27.327	113.667	8.167	5.833	13.600	16.583	1.270	24.580	10.350
1 x 4	20.610	118.000	7.233	5.867	10.800	10.337	1.177	17.310	8.947
1 x 5	36.927	117.000	6.783	5.167	19.267	16.620	1.217	17.273	13.660
1 x 6	18.987	113.333	7.733	6.167	12.800	11.040	1.537	17.137	9.233
1 x 7	29.787	118.667	7.267	5.667	16.867	16.113	0.857	16.523	11.320
2 x 3	32.143	115.667	8.033	5.133	16.400	13.380	0.900	14.613	5.733
2 x 4	24.903	114.333	10.067	5.900	10.533	15.447	1.493	23.110	7.307
2 x 5	27.670	114.333	7.333	5.533	12.667	15.983	1.297	20.543	12.977
2 x 6	20.917	114.333	7.233	5.267	10.467	11.613	1.160	23.633	7.980
2 x 7	27.593	114.667	8.500	5.733	13.533	15.740	1.127	21.350	13.677
3 x 4	24.443	117.333	9.033	5.387	10.667	11.270	1.330	25.003	7.810
3 x 5	21.433	114.333	7.867	6.133	12.867	11.523	1.127	17.150	8.690
3 x 6	30.147	119.000	7.517	5.767	13.333	17.637	1.287	19.133	13.573
3 x 7	13.177	114.667	7.243	5.620	6.867	8.123	1.083	22.413	7.053
4 x 5	27.293	120.333	8.200	5.567	13.533	13.587	1.430	19.097	10.703
4 x 6	30.683	115.667	7.850	5.587	15.533	16.203	1.480	18.953	10.013
4 x 7	35.210	116.000	6.050	6.100	12.067	11.293	1.027	15.897	10.733
5 x 6	18.530	116.333	6.637	5.733	9.867	15.887	1.113	20.013	8.120
5 x 7	17.773	115.000	7.250	5.067	13.467	10.027	1.000	15.840	8.583
6 x 7	20.657	115.000	7.117	4.933	8.133	6.797	1.077	23.800	6.847
1	18.283	114.667	6.617	5.733	13.800	10.597	1.050	15.247	6.677
2	23.727	115.333	8.500	5.133	11.400	15.413	1.320	26.603	12.073
3	28.537	117.667	8.367	5.400	15.200	16.630	1.093	19.063	11.647
4	25.090	117.333	6.900	5.833	14.600	12.833	1.153	19.823	11.127
5	11.603	116.000	7.700	5.820	7.700	6.370	0.850	19.540	5.623
6	19.443	118.667	5.767	5.557	13.667	11.593	0.923	15.313	7.267
7	9.800	116.667	6.600	3.600	6.500	4.130	0.800	17.080	3.740
LSD 0.05	6.657	4.811	1.699	0.694	2.721	3.416	0.323	2.680	3.082

Data in Table 4 explain the heterosis for the crosses estimated as the percentage of F_3 deviation from mid parental values. Maximum positive heterosis values for whole plant weight, days number to 50% flowering, pod length, seed number pod, pods number plant^{-1}, pod weight plant^{-1}, seeds weight pod^{-1}, 100-seed weight and seed weight plant^{-1}, were 147.111, 3.143, 30.736, 31.298, 89.671, 118.832, 55.743, 46.944 and 122.114 % respectively recorded by the crosses 1x5, 4x5, 2x4, 2x7, 5x7, 1x7, 1x6, 6x7 and 1x5 respectively. Maximum negative heterosis values for these characters were -31.258, -6.087, -10.370, -6.074, -36.713, -23.498, -25.114, -36.000 and -51.658 % recorded by the crosses 3x7, 1x2, 4x7, 1x2, 3x7, 3x4 and the cross 2x3 for the rest respectively. Positive values of heterosis confirm the effect of over dominance gene effect for the parent of higher value while the negative heterosis value reflect to the partial dominance genes effect for the parent with lower value. Positive and negative heterosis values recorded perversely on F_1 crosses by several researchers (2 and 23) and F_2 crosses and their parents (3).

Table 4. % Heterosis value for F_3 crosses

Crosses	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	pod weight plant^{-1} (g)	Seed weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
1 x 2	54.773	-6.087	-1.213	-6.074	8.995	43.150	-5.063	16.718	51.253
1 x 3	16.731	-2.152	9.010	4.790	-6.207	21.817	18.507	43.282	12.971
1 x 4	-4.965	1.724	7.028	1.441	-23.944	-11.766	6.808	-1.283	0.506
1 x 5	147.111	1.445	-5.239	-10.560	79.225	95.914	28.070	-0.690	122.114
1 x 6	0.654	-2.857	24.899	9.241	-6.796	-0.496	55.743	12.151	32.441
1 x 7	112.131	2.594	9.962	21.429	66.174	118.832	-7.387	2.227	117.344
2 x 3	23.005	-0.715	-4.743	-2.532	23.308	-16.488	-25.414	-36.000	-51.658
2 x 4	2.028	-1.719	30.736	7.599	-18.974	9.370	20.755	-0.445	-37.011
2 x 5	56.637	-1.153	-9.465	1.035	32.635	46.748	19.508	-10.959	46.657
2 x 6	-3.096	-2.279	1.402	-1.466	-16.489	-13.997	3.418	12.763	-17.477
2 x 7	64.605	-1.149	12.583	31.298	51.210	61.078	6.289	-2.251	72.976
3 x 4	-8.839	-0.142	18.341	-4.095	-28.412	-23.498	18.398	28.596	-31.411
3 x 5	6.793	-2.140	-2.075	9.329	12.373	0.203	15.952	-11.148	0.637
3 x 6	25.663	0.705	6.368	5.263	-7.621	24.979	27.603	11.316	43.532
3 x 7	-31.258	-2.134	-3.207	24.889	-36.713	-21.741	14.437	24.025	-8.319
4 x 5	48.765	3.143	12.329	-4.462	21.375	41.503	42.762	-2.972	27.801
4 x 6	37.799	-1.977	23.947	-1.902	9.906	32.669	42.536	7.884	8.880
4 x 7	101.834	-0.855	-10.370	29.329	14.376	33.150	5.119	-13.847	44.395
5 x 6	19.369	-0.852	-1.436	0.791	-7.644	76.879	25.564	14.843	25.989
5 x 7	66.080	-1.146	1.399	7.573	89.671	90.984	21.212	-13.490	83.339
6 x 7	41.274	-2.266	15.094	7.754	-19.339	-13.547	24.952	46.944	24.409
S.E	9.645	0.450	2.526	2.538	7.743	9.165	3.983	4.263	10.110

The estimation of gca effect for the parents represent in Table 5. Parent 2 and 3 recorded maximum positive gca effect values for all characters this indicated the highest contribution of these parents in the inheritance of these characters. Paren7 produced maximum negative gca effect values for most characters including whole plant weight, pods number plant^{-1}, pod weight plant^{-1}, seed weight pod^{-1} and seed weight plant^{-1}, indicating that the contribution of this parent in reducing the character mean in its crosses. Similar results were recorded perversely on these parents by (2 and 23) and F_2 crosses and their parents (3).

Table 5. Estimation of gca for the parents

Parents	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	pod weight plant^{-1} (g)	Seed weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
1	1.089	-0.921	-0.268	0.184	0.130	0.806	0.006	-1.060	0.572
2	2.253	-1.587	0.593	-0.264	-0.129	2.039	0.057	2.623	1.122
3	1.425	0.413	0.478	0.118	0.064	0.947	-0.005	0.416	0.067
4	2.268	1.116	0.215	0.274	0.220	0.061	0.113	0.193	0.208
5	-2.231	0.339	-0.092	0.137	0.083	-0.765	-0.038	-0.920	-0.213
6	-1.568	0.524	-0.519	0.106	0.052	-0.099	0.030	-0.442	-0.622
7	-3.235	0.116	-0.408	-0.555	-0.420	-2.989	-0.162	-0.810	-1.134
S.E	1.107	0.800	0.283	0.261	0.115	0.568	0.054	0.446	0.512

The estimation of the sca effect for F_3 crosses represent in Table 6. Maximum positive sca effect values for whole plant weight, days number to 50% flowering, pod length, seeds number pod^{-1}, pods number plant^{-1}, pod weight plant^{-1}, seed weight pod^{-1} , 100-seed weight and seed weight plant^{-1} were 13.955, 3.685, 0.894, 0.88, 5.459, 5,390, 0.184, 5.564 and

4.641 recorded by the crosses 1x5, 1x7, 1x6, 4x7, 1x5, 1x6, 4x6, 1x3 and 3x6 respectively, while maximum negative sca effect values were -9.128, -5.278, -0.574, -0.558, -4.311, -3.437, -0.141,-3.146 and -4.944 recorded by the crosses 3x7, 1x2, 2x3, 1x5, 3x7, 1x3, 1x7, 4x7, and 2x3 respectively. The positive sca value caused increase in the character value in compare to their parent, while the negative effect of sca value cause a decrease in the character value in compare to their parents. Similar results recorded by (2 and 23) and F_2 crosses and their parents (3).

Table 6. Estimation of sca for the F_3 crosses

Crosses	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	Pod weight plant^{-1} (g)	Seed weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant (g)
1 x 2	5.054	-5.278	-0.395	-0.410	-0.415	1.924	-0.091	3.201	2.999
1 x 3	0.698	-1.611	0.420	0.127	-0.993	-3.437	0.116	5.564	0.224
1 x 4	-6.861	2.019	-0.251	0.005	-3.593	3.673	-0.096	-1.483	-1.320
1 x 5	13.955	1.796	-0.394	-0.558	5.459	-2.573	0.096	-0.407	3.814
1 x 6	-4.649	-2.056	0.984	0.472	-1.052	5.390	0.347	-1.021	-0.204
1 x 7	7.819	3.685	0.405	0.444	4.519	-2.513	-0.141	-1.266	2.395
2 x 3	4.351	1.056	-0.574	-0.314	3.422	0.440	-0.306	-8.085	-4.944
2 x 4	-3.731	-0.981	1.721	0.297	-2.244	1.803	0.170	0.634	-3.511
2 x 5	3.534	-0.204	-0.705	0.068	0.474	-3.234	0.124	-0.819	2.580
2 x 6	-3.883	-0.389	-0.377	-0.169	-1.770	3.783	-0.081	1.793	-2.008
2 x 7	4.462	0.352	0.778	0.770	2.800	-2.645	0.078	-0.122	4.201
3 x 4	-3.364	0.019	0.803	-0.409	-2.556	-1.565	0.069	4.734	-1.952
3 x 5	-1.875	-2.204	-0.056	0.475	0.230	3.882	0.017	-2.006	-0.651
3 x 6	6.175	2.278	0.022	0.138	0.652	-2.741	0.108	-0.500	4.641
3 x 7	-9.128	-1.648	-0.364	0.464	-4.311	1.384	0.097	3.148	-1.367
4 x 5	3.143	3.093	0.539	-0.248	1.096	3.334	0.202	0.164	1.222
4 x 6	5.869	-1.759	0.617	-0.197	3.052	1.314	0.184	-0.457	0.940
4 x 7	12.063	-1.019	-1.295	0.788	1.089	3.844	-0.078	-3.146	2.172
5 x 6	-1.785	-0.315	-0.289	0.086	-2.030	0.874	-0.032	1.716	-0.532
5 x 7	-0.874	-1.241	0.212	-0.108	3.074	-3.022	0.047	-2.089	0.443
6 x 7	1.345	-1.426	0.507	-0.211	-2.304	1.606	0.055	5.393	-0.885
S.E	3.130	2.263	0.799	0.327	1.280	1.924	0.152	1.260	1.449

Data in Table 7 explain the variance due to gca effect ($\sigma^2_{\hat{g}ii}$) for the parents. Maximum value due to this variance for days number to %50 flowering, pod length and 100-seed weight were 0.600, 0.112, 6.283 respectively recorded by parent 2, while maximum values for whole plant weight, seeds number pod^{-1}, pods number plant^{-1}, pod weight plant^{-1} seed weight pod^{-1} and seed weight plant^{-1} were 6.793, 0.136, 2.558, 7.966, 0.018 and 0.498 respectively recorded by parent 7. High value due to this variance recorded by parents 2 and 7 indicate to their contribution in increasing the value of these characters in their crosses, while the low value of ($\sigma^2_{\hat{g}ii}$) for the parents indicate to the contribution of these parents in redaction the value of these characters in their crosses.

Table 7. Estimation of ($\sigma^2_{\hat{g}ii}$) for the parents

Parents	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	Pod weight plant^{-1} (g)	Seed weight pod (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
1	-2.490	-1.072	-0.168	-0.023	2.055	-0.319	-0.009	0.527	-0.461
2	1.400	0.600	0.112	-0.023	-0.614	3.191	-0.005	6.283	0.472
3	-1.643	-1.749	-0.011	-0.036	-0.399	-0.071	-0.009	-0.423	-0.783
4	1.467	-0.673	-0.193	0.008	-0.545	-0.964	0.004	-0.558	-0.744
5	1.304	-1.805	-0.231	-0.033	-0.511	-0.382	-0.007	0.251	-0.742
6	-1.217	-1.645	0.030	-0.037	-0.537	-0.958	-0.008	-0.400	-0.401
7	6.793	-1.906	-0.073	0.136	2.558	7.966	0.018	0.061	0.498

Data in Table 8 represent the estimation of ($\sigma^2_{\hat{s}ij}$) for the parents. Maximum value due to this variance for most characters recorded by parent 1 including whole plant weight, days to 50% flowering, pods number plant^{-1}, pod weight plant^{-1} and seed weight pod^{-1} with 340.941, 50.519, 63.779, 70.347 and 158 respectively. Maximum value due to seed weight plant^{-1} was 72.023 recorded by parent 2. Parent's recorded high value due to ($\sigma^2_{\hat{s}ij}$)

shows their contribution in transferring the character to a few number of their crosses, while parent recorded low values indicate to their contribution to transfer the characters to most their crosses.

Table 8. Estimation of ($\sigma^2_{\hat{s}ij}$) for the parents

Parents	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	Pod weight plant^{-1} (g)	Seed Weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
1	340.941	50.519	1.055	0.811	63.779	70.347	0.158	44.652	29.042
2	96.224	25.210	4.064	0.876	26.508	40.195	0.136	78.349	72.023
3	146.042	11.432	0.659	0.636	36.679	39.507	0.110	131.357	50.064
4	252.509	13.695	5.391	0.872	34.565	31.221	0.101	33.587	22.906
5	214.928	14.288	0.447	0.517	43.240	34.107	0.046	10.631	21.533
6	104.609	9.753	1.203	0.256	21.794	64.637	0.154	35.182	25.493
7	312.457	21.031	2.879	1.682	62.785	62.504	0.047	54.875	30.950

The estimation of some genetic parameters represent in Table 9. Respect to the ratio of $\sigma^2_{gca}/\sigma^2_{sca}$ was less than one for all characters while the average degree of dominance was more than one for all characters confirming the importance of non addictive gene effect in controlling the inheritance of these characters. Similar results recorded by (2, 3 and 17). Previous researches confirmed the importance of both additive and non additive gene effect in controlling pods number plant^{-1} and pod length, while the others indicated to importance of additive gene effect in controlling the inheritance of pod length (5, 7 and 9), and for 100-seed weight (12). The additive and non additive gene actions were predominating for the expression of seed yield (1, 6 and 9). While the importance of non additive gene action on seed weight plant^{-1} reported by (10). Heritability in broad sense was found to be high for pods number plant^{-1}, pod weight plant^{-1}, 100-seed weight and seed weight plant^{-1} reaching 0.755, 0.781, 0.769, 0.828 and 0.697 respectively, while it was moderate for seeds number pod^{-1} and seed weight pod^{-1} with 0.558 and 0.435 and it was low for the others. Heritability in narrow sense was found to be low for all characters. Similar results recorded perversely by (2, 17 and 23) and F_2 crosses and their parents (3).

Table 9. Estimation of some genetic parameters for the studied characters

Parameters	Whole plant weight (g)	Days to 50% flowering	Pod length (cm)	Seeds no. pod^{-1}	Pods no. plant^{-1}	Pod weight plant^{-1} (g)	Seeds weight pod^{-1} (g)	100-seed weight (g)	Seed weight plant^{-1} (g)
Mse´	5.512	2.879	0.359	0.060	0.921	1.451	0.013	0.894	1.181
σ^2gca	1.537	0.181	0.050	0.013	0.316	0.793	0.002	0.517	0.142
$\sigma^2_{sca} = \sigma^2 D$	13.951	0.653	0.067	0.050	2.652	3.235	0.006	3.275	2.439
$\sigma^2_{gca}/\sigma^2_{sca}$	0.110	0.278	0.750	0.258	0.119	0.245	0.334	0.158	0.058
σ^2A	3.074	0.363	0.100	0.026	0.632	1.585	0.004	1.035	0.285
ā	3.013	1.897	1.155	1.969	2.896	2.020	1.730	2.516	4.137
$h^2_{b.s}$	0.755	0.261	0.318	0.558	0.781	0.769	0.435	0.828	0.697
$h^2_{n.s}$	o.136	0.093	0.191	0.190	0.150	0.253	0.174	0.199	0.073

RECOMMENDATION

Further works to obtain crosses recommended and using such project in the region as a future program. All studied characters showed the non additive gene effect in controlling their inheritance which can be exploited by adopting the heterosis breeding program. According to our results we recommend continuing research on cross Avolla×Americana and parent Americana for its superiority in seed weight plant^{-1} and some its components. Further testing on the superior parents and crosses were needed to apply in different conditions to ensure their genetic stability.

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