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**COMBINING ABILITY ANALYSIS FOR VARIOUS QUANTITATIVE TRAITS IN
CHICKPEA (*CICER ARIETINUM* L.)**

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ABSTRACT

The present studies were conducted in the field of the department of Plant Breeding and Genetics, University of Agriculture, Faisalabad, during the crop season 2008-2009. It was concluded from 4 x 4 diallel crossing fashion that the SCA effects were highly significant for all traits but GCA effects were significant only for the traits biomass per plant, 100-seed weight and grains per plant and non-significant for all other traits. The genotypes Noor 91 and 9605 showed higher GCA effect nearly for all traits the crosses Noor 91 VS Bittle 98, Bittle 98 VS 9605, Noor 91 VS 9605 and 9605 VS 848 showed higher GCA effects for all most all traits. So selection of higher yielding chickpeas genotypes can be made on the basis of the number of days taken to flowering, number of days taken to maturity, biomass per plant, seeds per pod, 100-seed weight and plant height that are the characters which contribute largely to grain yield per plant.

Keywords: Chickpea, *Cicer arietinum*, SCA, GCA, genotypes, combining ability, Pakistan

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important grain legume in Pakistan and plays a dominant role in the agriculture of rainfed

areas of the country. It is third most important pulse crop after dry bean and pea. Pakistan ranks second to India in terms of acreage

under chickpea which is 1094 thousand hectares with an annual production of 760 thousand tones and an average yield of 720 kg ha⁻¹ [2]. It is rich and readily available source of protein both for human and animals. The average of chickpea yield in Pakistan is low compared to other chickpea growing countries. This may be attributed to the lack of high yielding varieties, resistant to diseases and pests, high response to high inputs and other management practices. Keeping in view these problems, it is of prime importance to evaluate the limiting factors contributing to growth and yield of chickpea. Chickpea is the cheapest and readily available source of protein (19.5%), fats (1.4%), carbohydrates (57-60), ash (4.8%) and (4.9-15.59%) moisture [8]. It makes up the deficiency of cereal diets. It also helps in replenishment of soil fertility by fixing of atmospheric nitrogen through symbiosis coupled with deep root system. Genetic variation among the plant traits is important for breeding and in selecting desirable types. The present study was initiated with the prime objective of observing the mutual relationships of different quantitative traits at seedling and maturity levels, also the type and extent of their contribution to seed yield. The studies thus clearly envisage augmenting the relatively scarce information available on these

characters which may be profitably exploited in future programmes of chickpea improvement.

MATERIALS AND METHODS

The present study was conducted in the experimental area of the Department of Plant Breeding and Genetics, University of Agriculture, Faisalabad during the year 2008-09. The genotypes Noor-91, Bittle-98, 9605 and 848 were crossed in 4 x 4 diallel fashion as given below. The F₁ and crosses were sown in a plot size of 4m x 1.2m in three replications using randomized complete block design. The plant-to-plant and row-to-row distances were 15 and 30cm, respectively. Analysis of variance for all characters, i.e. Viz number of days taken to flowering, number of days taken to maturity, primary branches per plant, secondary branches per plant, plant height, biomass per plant, number of pods per plant, number of seeds per pod, number of grain per plant, 100-seed weight and grain yield per plant were carried out using analysis of variance technique and Duncan Multiple Range (DMR) Test at 5% significance level was used to compare the treatments means[9]. The combining ability analysis was performed using mean values following Model I of Griffing's method [6]. The statistical t-student test was applied to

examine the effects of general combining ability (GCA) and specific combining ability (SCA). GCA/SCA ratios with a theoretical maximum of unity were computed according to Baker [3] as follows:

$$GCA/SCA = 2S_{gi} / (2S_{gi} + 2S_{sij})$$

Where g_i is the GCA effect of parent i and s_{ij} is the SCA effect of the Cross $i \times j$.

Noor 91	Bittle 98 vs 9605
Bittle 98	Bittle 98 vs 848
9605	9605 vs Noor 91
848	9605 vs Bittle 98
Noor 91 VS Bittle 98	9605 vs 848
Noor 91 VS 9605	848 vs Noor 91
Noor 91 vs 848	848 vs bittle 98
Bittle 98 vs noor 91	848 vs 9605

RESULTS AND DISCUSSIONS

The combining ability analysis was performed using mean values following Model I of Griffing's method [6]. The statistical t-student test was applied to examine the effects of general combining ability (GCA) and specific combining ability (SCA). The ANOVA (Tables 1) for combining ability indicated that the SCA effects were highly significant for all traits but GCA effects were significant only for the traits dry plant weight, 100-seed weight and grains per plant and non-significant for all other traits. The higher and positive GCA effects were found for Noor-91 and Bittle-98 but negative for 9605 and 848

for number of day taken to flowering (Table 2). The higher and positive SCA effects were found for cross Noor 91 VS Bittle 98 followed by 9605 vs 848 while the other crosses have negative SCA effects. The higher GCA effects indicated that Noor-91 and Bittle-98 have more additive effects so the selection for next generation will be effective and the cross Noor 91 VS Bittle 98 followed by 9605 vs 848 can be selected for good specific combiners for next generation for number of day taken to flowering in chickpea [1, 7]. The higher and negative GCA effects were found for Noor-91 and Bittle-98 but negative for 9605 and 848 for number of

day taken to maturity (**Table 2**). The higher and positive GCA effects were found for 9605. The higher and positive SCA effects were found for cross Noor 91 VS 848 followed by Bittle 98 vs 9605; Noor 91 VS 9605 and Bittle 98 vs 848 while the other crosses have negative SCA effects. The higher GCA effects indicated that Noor-91 and 848 have more additive effects so the selection for next generation will be effective and the cross Noor 91 VS 848 followed by Bittle 98 vs 9605; Noor 91 VS 9605 and Bittle 98 vs 848 can be selected for good specific combiners for next generation for number of day taken to maturity in chickpea [1, 5, 7].

The higher and negative GCA effects were found for 9605 followed by Noor-91 and 848 but negative GCA effects for Bittle-98 for plant height (**Table 2**). The higher and positive GCA effects were found for 9605. The higher and positive SCA effects were found for cross Noor 91 VS 9605 followed by Noor 91 VS Bittle-98 and Noor 91 VS 848 has highest negative SCA effects followed by Bittle 98 vs 9605 while the other crosses have positive SCA effects. The higher GCA effects indicated that 9605, Noor-91 and 848 have more additive effects so the selection for next generation will be effective and the cross

Noor 91 VS 9605 followed by 9605 vs 848 can be selected for good specific combiners for next generation for plant height in chickpea. The higher and negative GCA effects were found for 9605 followed by Noor-91, 848, and Bittle-98 which was positive GCA effects for number of primary branches per plant (**Table 2**) [5, 7, 10]. The higher and positive GCA effects were found for 9605. The higher and positive SCA effects were found for cross Noor 91 VS 848 followed by 9605 vs 848 while negative SCA for the other crosses. The positive GCA effects indicated that Noor-91, Bittle-98 and 848 have more additive effects so the selection for next generation will be effective and the cross Noor 91 VS 848 followed by 9605 vs 848 can be selected for good specific combiners for next generation for number of primary branches per plant in chickpea. The higher and positive GCA effects were found for Noor-91 followed by 9605 but 848 and Bittle-98 which were negative GAC effects for number of secondary branches per plant (**Table 2**).

The higher and positive GCA effects were found for Noor-91. The higher and positive SCA effects were found for cross Bittle-98 VS 9605 followed by Bittle-98 VS 848 while positive SCA for the other crosses except

Noor 91 VS Bittle 98 and Noor 91 VS 9605. The positive GCA effects indicated that Noor-91 and 9605 have more additive effects so the selection for next generation will be effective and the cross Bittle-98 VS 9605 followed by Bittle-98 VS 848 can be selected for good specific combiners for next generation for number of secondary branches per plant in chickpea. The higher and positive GCA effects were found for 9605 followed by Noor-91 and Bittle-98; 848 which has higher but negative GCA effects for biomass per plant (Table 2). The higher and positive GCA effects were found for 9605. The higher and positive SCA effects were found for cross Noor 91 VS 9605 followed by Noor 91 VS 848, Bittle 98 vs 9605 and 9605 vs 848 while negative and highest SCA for the crosses Bittle 98 vs 848 followed by Noor 91 VS Bittle 98 [3, 4, 8]. The positive GCA effects indicated that Noor-91 and 9605 have more additive effects so the selection for next generation will be effective and the cross Bittle-98 VS 9605 followed by Bittle-98 VS 848 can be selected for good specific combiners for next generation for biomass per plant in chickpea. The higher and positive GCA effects were found for 9605 followed by Noor-91 and Bittle-98; 848 which has higher but negative GCA effects for number of pods per plant (Table 2). The higher and positive

GCA effects were found for 9605. The higher and positive SCA effects were found for cross Bittle 98 vs 9605, 9605 VS 848 followed by Noor 91 VS Bittle 98 while negative and highest SCA for the crosses Noor 91 VS 9605 followed by Noor 91 vs 848. The positive GCA effects indicated that Noor-91 and 9605 have more additive effects so the selection for next generation will be effective and the cross Bittle 98 vs 9605, 9605 VS 848 followed by Noor 91 VS Bittle 98 can be selected for good specific combiners for next generation for number of pods per plant in chickpea [4, 5, 8, 10]. The higher and positive GCA effects were found for Noor 91 followed by 848 and Bittle-98; 9605 which has negative GCA effects for number of seeds per pod (Table 2). The higher and positive GCA effects were found for Noor 91. The higher and positive SCA effects were found for cross Bittle 98 vs 9605, Noor 91 VS 9605 followed by Noor 91 vs 848 while negative SCA for other crosses. The positive GCA effects indicated that Noor-91 and 848 have more additive effects so the selection for next generation will be effective and the cross Bittle 98 vs 9605, Noor 91 VS 9605 followed by Noor 91 vs 848 can be selected for good specific combiners for next generation for number of seeds per pod in chickpea [1, 7, 10]. The higher and positive GCA effects were found for Noor 91, Bittle-

98 followed by 848 and 9605 which has negative GCA effects for 100-seed weight (**Table 2**). The higher and positive GCA effects were found for Noor 91. The higher and positive SCA effects were found for cross Noor 91 VS Bittle 98, Bittle 98 vs 9605, Noor 91 VS 9605 followed by 9605 vs 848 while negative SCA for other crosses. The positive GCA effects indicated that Noor-91, Bittle 98 and 848 have more additive effects so the selection for next generation will be effective and the cross Noor 91 VS Bittle 98, Bittle 98 vs 9605, Noor 91 VS 9605 followed by 9605 vs 848 can be selected for good specific combiners for next generation for 100-seed weight in chickpea [4, 5]. The higher and positive GCA effects were found for Noor-91 followed by 9605 and Bittle-98 which has negative but 848 has highest negative GCA effects for number of grains per plant (**Table 2**). The higher and positive GCA effects were found for Noor-91. The higher and positive SCA effects were found for cross Noor 91 vs 848 followed by Noor 91 VS Bittle 98 and 9605 vs 848 while negative and highest SCA for the crosses Bittle 98 vs 848 followed by Noor 91 VS 9605. The positive GCA effects indicated that Noor-91 and 9605 have more additive effects so the selection for next generation will be effective and the cross Noor 91 vs 848 followed by Noor 91 VS

Bittle 98 and 9605 vs 848 can be selected for good specific combiners for next generation for number of grains per plant in chickpea [4, 7, 10]. The higher and positive GCA effects were found for Bittle-98 followed by 9605 and 848 which has negative but Noor-91 has highest negative GCA effects for grain yield per plant (**Table 2**). The higher and positive GCA effects were found for Bittle-98. The higher and positive SCA effects were found for cross 9605 vs 848, Noor 91 vs Bittle-98 followed by Bittle 98 vs 848, Noor 91 VS Bittle 98 and Noor 91 VS 848 while negative and SCA for the cross Noor 91 VS 9605. The positive GCA effects indicated that Bittle-98 and 9605 have more additive effects so the selection for next generation will be effective and the cross 9605 vs 848, Noor 91 vs Bittle-98 followed by Bittle 98 vs 848, Noor 91 VS Bittle 98 and Noor 91 VS 848 can be selected for good specific combiners for next generation for number of grain yield per plant in chickpea [3, 5, 7, 10].

CONCLUSIONS

It was concluded that the SCA effects were highly significant for all traits but GCA effects were significant only for the traits dry plant weight, 100-seed weight and grains per plant and non-significant for all other traits. The genotypes Noor 91 and 9605 showed

higher GCA effect nearly for all traits the crosses Noor 91 VS Bittle 98, Bittle 98 VS 9605, Noor 91 VS 9605 and 9605 VS 848 showed higher GCA effects for all most all traits. So selection of higher yielding chickpeas genotypes can be made on the basis of the number of days taken to flowering, number of days taken to maturity, biomass per plant, seeds per pod, 100-seed weight and plant height that are the characters which contribute largely to grain yield per plant.

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Table 1: Analysis of Variance of Combining Ability for Various Quantitative Traits in Chickpea

SOV/Taits	DF	NDF	NDM	PH	NPB	NSB	BM	NPP	NSPP	HSW	NGP	GY
Gca (MS)	3	2.045Ns	1.779Ns	14.081Ns	0.007Ns	0.127Ns	25.754**	107.154**	0.003Ns	1.717**	31.556*	1.437Ns
Sca(MS)	6	2.938**	1.748**	16.105**	0.005**	0.557**	11.379**	48.181**	0.007**	0.401**	40.949**	4.020**
Reciprocal (MS)	6	5.370*	1.074**	17.752**	0.011**	0.182**	12.123**	84.317**	0.004**	1.453**	11.485*	4.167**
Error (MS)	30	1.656	0.659	5.486	0.004	0.106	3.436	15.547	0.002	0.4811	9.436	1.231

* = Significant at 5% probability level; ** = Highly significant at 1% probability level; Ns = Non-Significant

NDF = Number of days taken to flowering, NPP = Number of pod per plant, NDM = Number of days taken to maturity, NSPP = Number of seeds per pod, PH = Plant height, HSW = 100-seed weight, NPB = Number of primary branches per plant, GYP = Grain yield per plant, NSB = Number of secondary branches per plant, NGP = Number of grains per plant, BM = Biomass per plant

Table 2: Combining Ability Effects for Various Quantitative Traits in Chickpea

Genotypes/Traits	NDF	NDM	PH	NPB	NSB	BM	NPP	NSPP	HSW	NGP	GY
Noor 91	0.500	-0.229	0.35	0.004	0.100	0.960	1.425	0.019	0.417	1.677	-0.537
Bittle 98	0.333	-0.146	-1.917	0.006	-0.038	0.398	-0.613	-0.016	0.206	-0.810	0.473
9605	-0.250	0.688	1.142	-0.039	0.096	1.277	3.921	-0.015	-0.653	1.565	0.144
848	-0.583	0.312	0.425	0.030	-0.158	-2.635	-4.733	0.012	0.029	-2.431	-0.079
Noor 91 VS Bittle 98	0.333	1	0.833	-0.002	-0.400	-1.983	-2.450	-0.073	-0.308	2.233	-0.308
Noor 91 VS 9605	0.333	0.167	5.533	-0.120	-0.500	-1.183	-4.033	-0.023	0.323	-0.733	-1.640
Noor 91 vs 848	2.333	-0.167	0.2	-0.095	0.067	1.533	7.200	-0.032	-0.025	-1.617	0.562
Bittle 98 vs Noor 91	1	-0.854	2.258	-0.042	-0.021	-0.931	0.492	0.012	0.191	2.473	1.229
Bittle 98 vs 9605	2.333	1.167	2.833	0.052	-0.317	-4.533	3.783	-0.048	0.782	-4.717	0.448
Bittle 98 vs 848	2.000	0.833	-433	-0.047	0.067	2.833	-8.600	-0.032	-0.967	0.017	3.033
9605 vs Noor 91	-1.750	0.146	2.567	-0.029	-0.321	1.023	6.592	0.007	0.376	-3.869	-1.747
9605 vs Bittle 98	-0.583	1.396	-2.867	-0.016	0.100	0.335	4.229	0.097	0.068	-0.631	0.021
9605 vs 848	-1.000	-0.333	3.7	0.068	0.167	-0.317	9.517	-0.018	-1.617	-2.017	0.037
848 vs Noor 91	-0.417	1.146	-4.583	0.070	0.267	1.752	3.904	0.062	-0.645	4.110	0.181
848 vs bittle 98	-0.917	0.062	0.25	-0.036	0.704	3.819	-0.467	-0.019	-0.296	-7.435	0.229
848 vs 9605	0.333	-0.604	0.658	0.004	0.171	0.085	2.617	-0.031	0.147	0.990	1.895

NDF = Number of days taken to flowering, NPP = Number of pod per plant, NDM = Number of days taken to maturity, NSPP = Number of seeds per pod, PH = Plant height, HSW = 100-seed weight, NPB = Number of primary branches per plant, GYP = Grain yield per plant, NSB = Number of secondary branches per plant, NGP = Number of grains per plant, BM = Biomass per plant