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Combining Ability of Selected Soybean [*Glycine max* (L.) Merrill] Parental Lines

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ABSTRACT

Background: The success of hybridization programme depends on the combining ability of parental lines.

Methods: Seven soybean genotypes and all their partial diallel crosses in the F_2 generation were evaluated in a randomized complete block design at two locations in Nigeria, during the 2017-2018 growing season.

Result: Analysis of variance showed that both environments and genotypes were significantly different for all measured traits. The genotype TGx 1988-5F was the best general combiner for earliness in flowering and poding, while TGx 1448-2E was the best general combiner for number of pods/plant and seed yield/plant. Crosses having significant and positive specific combining ability effect for number of pods/plant and seed yield/plant were TGx 1485-1D × TGx 1448-2E and TGx 1988-5F × TGx 1989-19F, respectively. Genotypes TGx 1988-5F and TGx 1448-2E exhibiting good general combining ability for earliness and seed yield/plant, are thus, promising for utilization in the future hybridization programme for soybean improvement.

Key words: General combining ability, Partial diallel, Soybean, Specific combining ability.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is one of the most important leguminous and oilseed crop in the world (Mikic and Peric, 2013). According to Agarwal *et al.* (2013), soybean contributes to about 26.7% of the global vegetable oil production and about two thirds of the world's protein concentrate for livestock feeding. Its richness in oil (20%) and protein (40%) content makes it an ideal crop to alleviate protein malnutrition in developing world (Bhartiya *et al.* 2018). Parent selection is one of the most critical aspects of any breeding programme, as its success depends directly on this step (de Almeida Lopes *et al.* 2001).

Diallel analysis formulated by Griffing (1956) helps breeders to evaluate newly developed cultivars for their parental usefulness and to assess gene action controlling inheritance of yield and its contributing traits in order to formulate efficient breeding programme (Susanto, 2018). Also, diallel crossing analysis is an excellent tool, which provide breeders with information on general and specific combining ability of parents and their hybrids (Nassar, 2013). According to Kearsey (1965), half diallel which involves a set of progeny and their parents have advantage over the other diallel techniques, because it provides the maximum information about genetic architecture of parents and traits. The use of Diallel analysis, excluding reciprocals for analyzing combining ability of soybean for yield and its related traits across environments have been reported by various authors (Paschal and Wilcox, 1975; Kaw and Menon, 1981; Cho and Scott, 2000).

Combining ability analysis is used to identify better parents, which can be hybridized to select better crosses for further breeding work (Murtadha *et al.* 2018). Combining ability study in soybean revealed significant estimated general and specific combing ability for yield and related traits (Agrawal *et al.* 2005; Gaviloli and Perecin, 2008; Abd El and Nassar, 2013). Aims of the study were to identify the best general combiners in soybean for measured traits and estimate the extent of additive and non-additive gene actions in-order to derive implications for further improvement of the populations generated from the crosses across environments.

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MATERIALS AND METHODS

Seven soybean parental lines (TGx 1989-19F, TGx 1987-10F, TGx 1988-5F, TGx 1987-62F, TGx 1835-10E, TGx 1448-

2E, TGx 1485-1D) obtained from the soybean breeding program of the International Institute of Tropical Agriculture (IITA) selected for various desirable traits (Table 1) were used for the crossing. To generate the F_1s, crossing was attempted among the seven selected parental lines (all are released varieties) in all possible combinations without reciprocals (partial diallel). The resulting 21 F_1 populations were further advanced to F_2. All the F_2s along with their parents were planted in the field at IITA, Ibadan (Longitude 7°30′N, Latitude 3°54′E) and Fashola (Longitude 6°49′N, Latitude 3°16′E) in Oyo State, Nigeria, during 2017 and 2018 growing season in a randomized complete block design (RCBD) with three replications. Each block was divided into 28 plots each measuring 2 m × 0.75 m and a distance of 0.75 m was allocated between blocks and plots. The number of rows for each plot was four rows with two harvestable middle rows and an intra and inter-row spacing of 10 cm and 75 cm, respectively.

Standard agronomic practices, like weeding, fertilizer application and pest management were done during the entire growing period. Data for five quantitative traits *viz.* days to flowering, days to poding, plant height, number of pods/plant and seed yield/plant were measured on forty randomly selected plants. Harvesting and threshing were done manually. Combining ability analysis after Griffing (1956) Method II, Model I using DIALLEL-SAS (Zhang and Kang, 1997) was performed.

RESULTS AND DISCUSSION

Combined analysis of variance of partial diallel crosses of soybean for yield and yield-related traits across locations revealed that the two environments were significantly different from each other (Table 2). Entries (parents and crosses) were significantly different from each other for all the traits studied, indicating sufficient genetic variability among the parents and crosses generated (Kose, 2019). Significant interaction between environment and entries was observed in all the measured traits, except for number of pods/plant and seed yield/plant. There were significant general combining ability (GCA) effects across environments

Table 1: Characteristics of soybean varieties used in the study.

Genotype	Year of release	Average on-farm yield (kg/ha)	Salient features
TGx 1989-19F	2014	1.5-3.0	Medium maturing, resistant to Asian rust, Cercospora leaf spot and Xanthomonas leaf pustule.
TGx 1987-10F	2010	1.5-2.5	Early maturing, resistant to Asian rust, Cercospora leaf spot and Xanthomonas leaf pustule.
TGx 1988-5F	2014	1.5-2.5	Early maturing, resistant to Asian rust, Cercospora leaf spot and Xanthomonas leaf pustule.
TGx 1987-62F	2010	1.5-2.5	Early maturing, resistant to Asian rust, Cercospora leaf spot and Xanthomonas leaf pustule.
TGx 1835-10E	2008	1.5-2.0	Early maturing, resistant to Asian rust, Cercospora leaf spot and Xanthomonas leaf pustule.
TGx 1448-2E	1992	1.3-2.0	Medium maturing, resistant to Cercospora leaf spot and Xanthomonas leaf pustule, susceptible to Asian rust.
TGx 1485-1D	1998	1.2-2.0	Early maturing, resistant to Cercospora leaf spot and Xanthomonas leaf pustule, susceptible to Asian rust.

Source: Soybean breeding unit, International Institute of Tropical Agriculture, Ibadan.

Table 2: Pooled analyses of variance of soybean for yield and yield-related traits in Ibadan and Fashola.

Source of variation	Degree of freedom	Days to flowering	Days to poding	Plant height (cm)	Number of pods/plant	Seed yield/ plant (g)
Environment	1	8091.45**	8472.14**	38892.80**	62541.50**	3242.05**
Replication (Environment)	4	120.40**	164.23**	108.32**	259.59*	498.40**
Genotype	27	22.73**	55.63**	83.99**	401.75**	174.38*
Environment × Genotype	27	17.30*	24.93*	58.49**	166.30	130.55
GCA	6	54.88**	145.46**	271.76**	1325.42**	334.558**
SCA	20	13.55	29.97**	30.35	137.84*	128.61*
GCA × Environment	6	25.83*	61.19**	163.37**	514.29**	79.08
SCA × Environment	20	14.86	14.57	28.52	66.88	145.25
Error	108	10.04	12.32	22.32	107.39	101.91
GCA/SCA		0.89	0.91	0.95	0.95	0.84

*, **Significant at 5% and 1% probability levels respectively.

for almost all the measured traits, except for days to poding. Similarly, the specific combining ability (SCA) effects across environments were significant for days to poding, number of pods/plant and seed yield/plant, exhibiting that variability in the breeding material can be attributed to both additive and non-additive gene effects. Highly significant GCA × environment interactions for almost all the measured traits showed that the performance of parents used in the study was influenced by environment and thus, testing under different environments will ensure selection of stable parents that can perform to the potential of that environment (Machado *et al*. 2009).

Greater magnitude of GCA compared to SCA was observed for all measured traits, which reveals the prevalence of additive gene action, indicating and that selection will be effective to improve the traits (Gravina *et al*., 2004; Nazim *et al*. 2014). The GCA: SCA ratio close to unity for all measured traits showed that the parents contributed mostly to the performance of the crosses observed, and influence of the environment was minimal and thus, there is preponderance of additive gene action controlling traits studied (Murtadha *et al*. 2018). Adsul *et al*. 2016 reported that additive gene action was found predominant in the inheritance of 100-seed weight and yield/plant in segregating population of soybean. Also, Umar *et al*. (2017) reported the importance of additive gene action in inheritance of days to 50% flowering, days to maturity, number of pods/ plant and 100-seed weight. Nassar (2013) also observed

Table 3: Pooled GCA effects of parental genotypes used in partial diallel crosses of soybean for yield and yield-related traits across Ibadan and Fashola.

Genotype	Days to flowering	Days to poding	Plant height (cm)	Number of pods per plant	Total seed weight (cm)
TGx 1989-19F	-0.11	0.04	-1.49	-1.10	1.70
TGx 1987-10F	0.64	0.42	2.36	-2.36	-1.41
TGx 1988-5F	-1.92*	-3.23*	-1.99	-4.18	-0.28
TGx 1987-62F	0.93	1.20	-0.19	-1.46	-0.62
TGx 1835-10E	-0.54	-0.77	-2.96	-4.05	-3.98*
TGx 1448-2E	0.08	0.55	2.61	9.58*	3.94*
TGx 1485-1D	0.91	1.79	1.67	3.57	0.66
S.E. (g_i)	0.64	0.99	1.61	2.86	1.12

*, **Significantly different at 5% and 1% probability levels respectively.

Table 4: Estimates of SCA effects of soybean crosses for yield and yield-related traits across Ibadan and Fashola.

Cross	Days to flowering	Days to poding	Plant height (cm)	Number of pods/plant	Seed yield/ plant (g)
TGx 1987-10F × TGx 1989-19F	0.61	0.35	-0.54	-2.59	-2.38
TGx 1988-5F × TGx 1989-19F	-0.22	-4.91*	0.19	-3.88	8.24*
TGx 1987-62F × TGx 1989-19F	0.36	-0.35	-0.27	-1.32	-3.30
TGx 1835-10E × TGx 1989-19F	-0.96	0.93	-0.48	-2.81	-4.24
TGx 1448-2E × TGx 1989-19F	-1.73	-0.36	-1.37	-4.86	-3.43
TGx 1485-1D × TGx 1989-19F	2.50*	3.58*	-3.05	1.45	-4.22
TGx 1988-5F × TGx 1987-10F	-0.10	0.64	1.55	6.09*	7.69
TGX 1987-62F × TGx 1987-10F	1.66	3.35*	-0.07	-2.24	0.66
TGx 1835-10E × TGx 1987-10F	-2.65*	-2.44	0.79	1.73	3.11
TGx 1448-2E × TGx 1987-10F	-2.09	-2.43	0.66	-0.52	-2.07
TGx 1485-1D × TGx 1987-10F	-1.36	-1.57	-0.07	-1.82	-1.52
TGx 1987-62F × TGx 1988-5F	0.50	0.49	-4.58*	-3.26	-7.39
TGx 1835-10E × TGx 1988-5F	-1.87	-0.85	-3.54	-0.32	-2.98
TGx 1448-2E × TGx 1988-5F	0.99	0.22	-0.64	-4.04	-2.49
TGx 1485-1D × TGx 1988-5F	-0.33	0.38	0.45	-0.87	1.71
TGx 1835-10E × TGx 1987-62F	2.21	1.16	-1.54	0.33	3.99
TGx 1448-2E × TGx 1987-62F	0.58	-2.45	1.83	-7.61	6.75
TGx 1485-1D × TGx 1987-62F	-0.50	-2.01	2.32	2.35	5.61
TGx 1448-2E × TGx 1835-10E	0.63	0.36	-2.89	-6.74*	-3.68
TGx 1485-1D × TGx 1835-10E	0.14	-3.52*	0.26	-0.78	1.79
TGx 1485-1D × TGx 1448-2E	-0.79	0.90	-0.51	6.34*	2.09
S.E. (S_{ij})	1.14	1.39	1.96	2.99	4.02

*, **Significantly different at 5% and 1% probability levels respectively.

high GCA: SCA ratio for earliness and number of pods/ plant in soybean.

The estimates of GCA effects of parental lines used in the study across Ibadan and Fashola (Table 3), revealed that TGx 1988-5F had desirable negative and significant GCA effect for days to flowering and poding. The parent TGx 1448-2E gave significant and positive GCA effect for number of pods/plant and seed yield/plant, showing the importance of this parent in improving these traits. Soybean parental lines with significant GCA have been reported by Durai and Subbalakshmi (2009). Good GCA in soybean for yield and its related traits have also been reported earlier by Srivastava *et al*. (1978) and Sharma and Phul (1994).

The SCA effects of the cross TGx 1835-10E × TGx 1989-10F was negative and significant and desirable for days to flowering (Table 4). Two crosses, TGx 1988-5F × TGx 1989-19F and TGx 1485-1D × TGx 1835-10E exhibited significant and positive SCA effects for days to poding. Significant good specific combining ability for reduced plant height was observed in cross TGx 1987-62F × TGx 1988-5F. Crosses having positive and significant SCA effects for number of pods/plant are TGx 1988-5F × TGx 1987-10F and TGx 1485-1D × TGx 1448-2E. Significant and positive SCA effect for seed yield/plant was observed in the cross TGx 1988-5F × TGx 1989-19F. Datt *et al*. (2011) have also reported crosses with good SCA for earliness and grain yield/plant in soybean. Crosses showing good specific combining ability for traits studied have either parent as good or average combiners. According to Kenga *et al*. (2004), cross combinations with favorable SCA estimates and involving at least one of the parents with good GCA estimate would likely enhance the concentration of favorable alleles to improve traits of interest.

Parental varieties of soybean used in the study had higher GCA than SCA showing preponderance of additive gene action controlling seed yield and its related traits. Hence, selection for measured traits at early growth of segregating populations might be effective. As evidenced by their significant GCA effects, the parental line TGx 1988-5F can be used to improve earliness, while TGx 1448-2E can be used to improve seed yield in soybean breeding program.

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