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Line x Tester Analysis Reveals Inheritance of Drought Tolerance in Greengram (*Vigna radiata* L.)

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Abstract

Greengram (*Vigna radiata* L.) is the third most important pulse crop of India. Crop experiences various kinds of droughts during cropping period. Five female lines and three male lines were identified from 200 germplasm lines screened for drought tolerance. Using these male and female parental lines, 15 crosses were generated using “Line x Tester” mating design. The analysis revealed that drought tolerance is governed by both additive and non-additive gene interactions. Inheritance of drought tolerance is considered to be a quantitative since many of the crosses did not show positive sca effects, while several parental lines recorded positive gca effects indicating the trait improvement is possible only through exploitation of gca effects. Several factors and mechanisms operate independently or jointly to enable plants to cope with drought stress.

Global yield losses due to drought were estimated as high as 351 billion annually. Mungbean being third most important pulse crop of India is mostly grown as secondary crop under varying climatic conditions and water regimes. It is often grown in rice fallows or after completion of main kharif crop utilising available soil moisture. Hence, the crop is exposed to various kinds of droughts like seedling drought and terminal drought. Drought stress is an important limitation to greengram production in India hence, requires constant and continued research efforts to stabilize production. Efforts to develop drought tolerant genotypes have been made, unless there is inbuilt tolerance for drought, increasing grain yield will be difficult. Therefore, the development of drought resistant cultivars with high yielding capacity is one of the main breeding objectives.

To design an efficient breeding programme for developing drought tolerant genotypes with high yielding ability, there is a need to study inheritance of various traits governing drought tolerance. The effectiveness of selection for secondary traits to improve yield under drought conditions has been demonstrated in greengram by Sunilkumar *et al.(*2015), rice by Manickavelu *et al*.(2006), maize (Chapman and Edmeades, 1999), wheat (Richards *et al*., 2000) and sorghum (Tuinstra *et al*.,1998).

The study material consisted of 200 greengram Germplasm collected from various organizations. All these 200 germplasm lines are screened for drought tolerance based on yield under drought stress and physiological traits such as; chlorophyll content based on SPAD reading, stomatal frequency, relative water content (RWC) and leaf surface area (LSA). Eight germplasm lines were identified as drought tolerant based on the parameters listed above. Of these eight lines, 5 lines treated as female parents and 3 lines treated as male parents. Using these eight parents, 15 crosses were generated by following “Line x Tester” mating design. The details of which is as follows

The results revealed the presence of fair amount of genetic variability among parents and hybrids (Table II). ANOVA also revealed significant differences among parents for their general combining ability effects and among crosses for their specific combining ability.

Among five female lines, several lines possessed highest positive *gca* effects for different traits such as IC-413319 for yield (20.81), IC-436594 for relative water content(1.52) KM13-23 for stomatal frequency (38.15). The line KM13-23 recorded highest positive *gca* effects for leaf surface area (2.52) and chlorophyll content (9.94).

Among three males, KM13-42 recorded highest positive *gca* effects for yield (2.470), leaf surface area (0.29), chlorophyll content (1.83), relative water content (0.79) and stomatal frequency (27.94) compared to other two lines.

TABLE I

Details of lines, testers and crosses used in the study

Line	Testers	Crosses		
		KM13-18 X KM13-42	KM13-23 X VBN-223	IC-413319 X IC-436746
KM13-18	KM13-42	KM13-18 X IC-436746	KM13-26 X KM13-42	IC-413319 X VBN-223
KM13-23	IC-436746	KM13-18 X VBN-223	KM13-26 X IC-436746	IC-436594 X KM13-42
KM13-26	VBN-223	KM13-23 X KM13-42	KM13-26 X VBN-223	IC-436594 X IC-436746
IC-413319		KM13-23 X IC-436746	IC-413319 X KM13-42	IC-436594 X VBN-223
IC-436594				

TABLE II

ANOVA for combining ability of yield and drought tolerance traits in Line x Tester (5 x 3) analysis

Source	df	Plot yield (gms)	Leaf surface area (sq.mm)	Chlorophyll content (SPAD Values)	Relative water content (RWC%)	Stomatal frequency per sq.cm
		Mean sum of squares				
Replication	2	59.07	35.25*	1325.61*	191.93*	255101.79*
Treatments	22	1021.28*	11.34*	301.61*	29.32	30700.79*
Parents	7	1049.11	4.37	66.21	14.07*	462.61
P vs C	1	6535.21*	98.66*	3751.75*	357.81*	599282.51*
Crosses	14	613.51*	8.59*	172.88*	13.47*	5206.90*
Lines	4	433.21*	7.09*	131.52*	9.36	1506.65
Testers	2	37.14	0.95	49.69	6.40	7903.29*
L x T	8	188.66	0.37	14.66	1.66	2147.14*
Error	44	195.21	2.73	55.01	4.29	1656.74

*significant at p=0.05

TABLE III

General combining ability effects of female and male parents involved in line x tester (5 x 3) analysis

Parents	Plot yield (gms)	Leaf surface area (sq.mm)	Chlorophyll content (SPAD Values)	Relative water content (RWC%)	Stomatal frequency per sq.cm
Females					
KM13-18	-13.52	1.19	6.13	-2.683	1.358
KM13-23	-0.3659	2.52	9.94	1.297	38.15
KM13-26	-11.51	-1.59	-6.46	1.559	-31.61
IC-413319	20.81	-1.12	-6.95	-1.71	-13.69
IC-436594	4.587	-0.99	-2.65	1.542	5.803
Males					
KM13-42	2.47	0.29	1.83	0.792	27.94
IC-436746	-1.83	0.10	1.11	0.221	7.66
VBN-223	-0.6373	-0.39	-2.94	-1.014	-35.60

TABLE IV

Specific combining ability effects of crosses involved in line x tester (5 x 3) analysis

Crosses	Plot yield (gms)	Leaf surface area (sq.mm)	Chlorophyll content (SPAD Values)	Relative waterm 'content (RWC)%	Stomatal frequency per sq.cm
KM13-18 X KM13-42	-2.88	-0.35	-2.27	-0.34	-15.79
KM13-18 X IC-436746	3.52	0.04	1.82	-0.22	-4.41
KM13-18 X VBN-223	-0.64	0.31	0.45	0.56	20.20
KM13-23 X KM13-42	-2.62	0.43	2.50	0.68	25.46
KM13-23 X IC-436746	-7.36	-0.02	-0.60	-0.05	-1.38
KM13-23 X VBN-223	9.97	-0.40	-1.90	-0.63	-24.08
KM13-26 X KM13-42	-2.44	-0.16	-0.93	-0.42	-15.24
KM13-26 X IC-436746	11.90	0.33	1.84	1.00	33.62
KM13-26 X VBN-223	-9.45	-0.17	-0.91	-0.58	-18.38
IC-413319 X KM13-42	4.46	0.11	0.75	0.17	9.08
IC-413319 X IC-436746	-2.06	-0.41	-3.05	-0.95	-35.43
IC-413319 X VBN-223	-2.41	0.30	2.30	0.77	26.35
IC-436594 X KM13-42	3.48	-0.03	-0.06	-0.10	-3.51
IC-436594 X IC-436746	-6.01	0.06	0.01	0.21	7.61
IC-436594 X VBN-223	2.53	-0.03	0.07	-0.12	-4.10

Among the fifteen crosses, the cross KM13-26 X IC-436746 had highest positive *sca* effect for yield (11.96). Similarly several other crosses recorded highest positive *sca* effects such as KM13-23 X KM13-42 for leaf surface area (0.43), IC-413319 X IC-436746 for stomatal frequency (25.46) and KM13-26 X IC-436746 for chlorophyll content (1.84) and also for relative water content (1.00).

The study reveals inheritance of drought tolerance and signifies the importance of exploitation of additive and non-additive genetic effects for drought tolerance breeding. Inheritance of drought tolerance is considered to be a quantitative since many of the crosses did not show positive sca effects for many of the traits indicating the trait improvement is possible only through exploitation of gca effects. Several factors and mechanisms operate independently or jointly to enable plants to cope with drought stress. It appears that SSD (single seed descent) method or bulk method of handling segregating generations can be utilized to exploit additive or additive x additive gene effects for improving drought tolerance. It is also suggested that parent IC-413319 with high *gca* effects for yield (20.81) could be used as parental line for drought tolerance breeding. The male parent KM13-42, which showed highest positive *gca* effects for all the traits could serve as potential donor in plant breeding programmes.

These research findings of drought inheritance mechanisms are in confirmation with reports made by Naveen Choudhary (2014) in mungbean, Sabry *et al.* (2011) in maize, Arash *et al.* (2013) in wheat and Ceyhan *et al.* (2014) in bean.

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