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EVALUATION OF ELITE GREENGRAM GENOTYPES FOR DROUGHT TOLERANCE USING STRESS INDICES

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ABSTRACT:

Selection for drought tolerance typically involves evaluating genotypes for either high yield potential or stable performance under drought stress. In order to select drought tolerant genotypes of greengram an experiment was conducted in a split plot design with three replications under different stress and non stress conditions during *rabi* season. Ten drought tolerance indices including stress tolerance index (STI), geometric mean productivity (GMP), mean productivity index (MP), stress susceptibility index (SSI), tolerance index (TOL), yield index (YI), yield stability index (YSI), drought resistance index (DI), relative drought index (RDI) and stress susceptibility percentage index (SSPI) were calculated and adjusted based on grain yield under water stress (Ys) and irrigated conditions (Yp). Screening drought tolerant genotypes using rank, distinguished genotype TRCRM-141 and IPM 2-14 as the most drought tolerant.

Key words: genotypes of greengram, drought stress indices, screening techniques.

INTRODUCTION:

Greengram *(Vigna radiata* L.) is an important pulse crop in India and believed to be originated from India. The protein is comparatively rich in lysine, an amino acid that is deficient in cereal grains. The seeds of greengram also contains fat 1.3%, minerals 3.5%, fiber 4.1% and carbohydrate 56%. Every 100 g of greengram seeds contain 124 mg calcium, 7.3 mg iron, 189 mg magnesium, 326 mg phosphorus and 1246 mg potassium and vitamins like 4.8 mg ascorbic acid, 0.621 mg thiamine, 0.233 mg riboflavin, 2.251 mg niacin, 1.910 mg pantothenic acid and 114 IU vitamin A (Haytowitz and Matthews, 1986). So, a diet combining greengram and cereal grains forms a balanced amino acid diet.

Among several reasons for low productivity, various abiotic and biotic factors play major role. Among the abiotic stresses, drought is a wide spread problem that seriously affects the greengram productivity. Though various agronomic management practices helps in mitigating the drought impact in greengram, drought tolerant varieties should be made more accessible to farmers than costly agronomic practices. Hence, there is an immediate need for plant breeders to develop drought tolerant varieties with higher yield. Surviving such stresses over a long evolutionary scale led them to acquire mechanisms by which they can sensitively perceive incoming stresses and regulate their physiology.

Generally, different strategies have been proposed for the selection of relative drought tolerance and resistance, so some researchers have proposed selection under non-stress conditions, others have suggested selection in the target stress conditions while, several of them have chosen the mid-way and believe in selection under both non-stress and stress conditions. Richard *et al*. believed that yield selection in the absence of drought is an effective method to improve yield in dry areas. Selecting greengram genotypes based on their yield performance under drought conditions is a common approach. Another approach to identify tolerant genotypes to dry environment is that some drought stress indices or selection criteria have been suggested by different researches. Stress tolerance index (TOL) and mean productivity (MP) were defined as the difference in yield and the average yield between stress and non-stress environments, respectively. Other yield-based index is geometric mean productivity (GMP) that is often used by breeders interested in relative performance, since drought stress can vary in severity in field environment over years. Another selection criterion for a high yielding cultivar under drought conditions is stress susceptibility index (SSI) proposed by Fischer and Maurer. Stress tolerance index (STI) was defined as a useful tool for determining high yield and stress tolerance potential of genotypes. Yield stability index (YSI) was also suggested by Bouslama and Schapaugh. This parameter is calculated for a given genotype using grain yield under stress relative to its grain yield under non-stress conditions. The genotypes with high YSI is expected to have high yield under stress and low yield under non-stress conditions. Lan defined a new drought resistance index (DI), which was commonly accepted to identify genotypes producing high yield under both stress and non-stress conditions. SSPI are able to separate relative tolerant and no tolerant genotypes. Fischer *et al.* introduced another index as relative drought index (RDI).

MATERIAL AND METHODS

The experiment was carried out at Agricultural Research Station, Kalaburagi for the year 2018 *Rabi* season. The soil of the experimental site was medium black with clay loam texture. The experiment was laid out in split plot design with two irrigation conditions as main plot and eight genotypes as sub plot. In which eight greengram genotypes were sown under stress (non-irrigated) and non-stress (irrigated) conditions. The normal package of practices was followed during the crop growth period. The observations were taken during the 20, 40, 60 DAS and after harvest. Eight genotypes are listed in table 1. At harvest time, yield potential (Yp) and stress yield (Ys) were measured and converted to kg ha^{-1}. Drought resistance indices were calculated using the following relationships:

Stress susceptibility index = SSI = $\frac{1-(Y_s/Y_p)}{1-(\bar{Y}_s/\bar{Y}_p)}$ (Fischer and Maurer, 1978)

Yield index = YI = $\frac{Y_s}{\bar{Y}_s}$ (Gavuzzi *et al.,* 1997)

Yield stability index = YSI $= \frac{Y_s}{Y_p}$ (Bouslama and Schapaugh, 1984)

Drought resistance index = DI = $Y_s \times \frac{Y_s/Y_p}{\bar{Y}_s}$ (Lan, 1998)

Stress susceptibility percentage index = SSPI = $[Yp-Ys/2(\bar{Y}p)]\times 100$ (Moosavi *et al.,* 2008)

Relative drought index = RDI = (Ys/Yp)/($\bar{Y}$s /$\bar{Y}$p) (Fischer and Wood, 1979)

Tolerance =TOL = Yp-Ys (Rosielle and Hambling, 1981)

Mean productivity = MP = Ys+Yp/2 (Rosielle and Hambling, 1981)

Stress tolerance index = STI =Ys X Yp/ $\bar{Y}p^2$ (Fernandez, 1992)

Geometric mean productivity = GMP = $\sqrt{(Yp)(Ys)}$ (Fernandez, 1992)

Where, Ys and Y_p are the yield of genotypes under stress and nonstress conditions, respectively. $\bar{Y}$s and $\bar{Y}$p are the mean yield of all genotypes under stress and non stress conditions, respectively.

YI used for screening drought tolerant high yielding genotypes in both the conditions (Fernandez, 1992; Mohammadi *et al.,* 2003) is related to yield under drought stress and is used if stress is not too severe and the difference between Ys and Yp is not too large. A genotype having higher YI value indicates that the genotype is more tolerant to drought stress (Fernandez, 1992; Gavuzzi *et al.,* 1997; Bouslama and Schapaugh, 1984; Hossain *et al.,* 1990). The stress susceptibility index is negatively correlated with yield. Thus, a small value of SSI is desirable and is being widely used to identify sensitive and tolerant genotypes (Clark *et al.,* 1992; Golabadi *et al.,* 2006).

Bouslama and Schapaugh (1984) indicated that yield stability index (YSI) with its positive values indicate stress tolerance. The genotypes with high YSI is expected to have high yield under stress and non-stress conditions as reported by (Mohammadi *et al.,* 2010). Lan (1998) reported the drought resistance index (DI) to identify genotypes producing high yield under both stress and non-stress conditions. The genotype that shows high drought resistance index (DSI) was the most relatively drought tolerant genotype according to Ezatollah *et al.,* 2012. SSPI index separates the relative tolerant and susceptible genotypes (Moosavi *et al.,* 2008).

Table 1. Names and codes of genotypes

Genotypes	Codes	Genotypes	Codes
TM 96-2	1	TRCRM-147	5

TRCRM-4	2	IPM 2-14	6
TRCRM-141	3	BGS-9	7
TRCRM-146	4	Selection-4	8

RESULTS AND DISCUSSION:

Analysis of variance and mean comparisons of yield under stress (Ys), yield under non stress (Yp) and drought tolerance indices showed that, there were high significant differences between greengram genotypes, indicating presence of high genetic diversity among them. Genotypes differed significantly for grain yield as revealed from significant mean squares attributable to genotypes (Table 2). These results justified the selection of the genotypes for the study. Moments of Ys, Yp and drought tolerance indices revealed the variation between genotypes. Non-receipt of rains during intended crop growth stage, *i.e.,* during pod filling and grain maturity stages suggested successful imposition of moisture stress, which is amply reflected by significant mean squares attributable to moisture regime (MR) in pooled ANOVA. Further, non-significant mean squares attributable to genotypes x MR interaction suggested comparable responses of genotypes in both stress and non-stress environments (Table 2). These results also suggest that the genotypes' performance for the grain yield under non-stress environment is a good indication of their performance under stress environments and *vice-versa*. This explains that the selected elite greengram genotypes will perform better under stress environment.

Table 2: Pooled analysis of variance of elite greengram genotypes evaluated for grain yield under stress and non-stress environments

Source of Variation	DF	Mean Squares	F-Calculated	Significance
Replication	2			
Genotypes (G)	7	2,29,156.688**	10.138	< 0.001
Moisture Regimes (MR)	1	8,41,905.188**	37.245	< 0.001
G x MR	7	6,195.616*	0.274	0.928
Error	30	22,604.346		
Total	47			

Decrease in the yield was highest in genotypes 5 and 6. The reduction in the yield values was least in genotypes 3, 7 and 8 in stress environment (Table 3). The same genotypes showed least values of SSI, TOL and SSPI indicating their increased level of drought tolerance compared to other genotypes. On the other hand the value of RDI was highest in the genotypes 3, 7 and 8 indicating their increased drought tolerance compared to genotypes 5 and 6 having lower values of RDI. The genotype 3 showed greater values of MP, GMP, DI and STI indices followed by the genotypes 6 and 2 with higher yield in stress condition. The YSI index was highest in the genotype 3 followed by 8 and 7 and the YI was highest in the genotype 2, 3 and 6. To summarise the genotypes 3, 6, 7 and 8 ranked top in most of the indices indicating their comparable performance in non-stress as well as stress condition with minimum reduction in yield *per se* (Table 4).

Table 3: Mean % reduction in seed yield (kg ha^{-1}) of the elite greengram genotypes

Genotypes	Seed Yield (kg ha^{-1}) under Non-stress environment	Seed Yield (kg ha^{-1}) under stress environment	Reduction in seed yield (kg ha^{-1})	Mean % reduction in seed yield (kg ha^{-1})
1	1019	772	247	24.24
2	1230	915	315	25.61
3	1554	1359	195	12.55
4	1130	862	268	23.72
5	1197	865	332	27.74
6	1288	932	356	27.64
7	1027	805	222	21.62
8	909	725	184	20.24

Table 4: Drought tolerance indices for Seed yield

Genotypes	SSI	RDI	TOL	MP	STI
1	1.07 (6)	0.98 (5)	247 (4)	896 (7)	0.576 (7)
2	1.02 (5)	0.97 (6)	315 (6)	1073 (3)	0.824 (3)
3	0.50 (1)	1.14 (1)	195 (2)	1457 (1)	1.545 (1)
4	0.95 (4)	0.99 (4)	268 (5)	996 (5)	0.713 (5)
5	1.11 (7)	0.94 (7)	332 (7)	1031 (4)	0.758 (4)
6	1.11 (7)	0.94 (7)	356 (8)	1110 (2)	0.878 (2)
7	0.86 (3)	1.02 (3)	222 (3)	916 (6)	0.605 (6)
8	0.81 (2)	1.04 (2)	184 (1)	817 (8)	0.482 (8)

GMP	YSI	YI	DI	SSPI
887 (7)	0.76 (4)	0.85 (7)	0.67 (6)	10.56 (4)
1061 (3)	0.74 (5)	1.01 (3)	0.77 (2)	13.47 (6)
1453 (1)	0.87 (1)	1.50 (1)	1.35 (1)	8.34 (2)
987 (5)	0.76 (4)	0.95 (5)	0.75 (3)	11.46 (5)
1018 (4)	0.72 (6)	0.96 (4)	0.71 (5)	14.20 (7)
1096 (2)	0.72 (6)	1.03 (2)	0.77 (2)	15.23 (8)
909 (6)	0.78 (3)	0.89 (6)	0.72 (4)	9.50 (3)
812 (8)	0.80 (2)	0.80 (8)	0.66 (7)	7.87 (1)

SSI = Stress susceptibility index, MP = Mean productivity, RDI = Relative drought index, STI = Stress tolerance index,
TOL = Tolerance, GMP = Geometric mean productivity, DI = Drought resistance index, YSI = Yield stability index
SSPI = Stress susceptibility percentage index, YI = Yield index

It is therefore desirable to preferentially use these indices for screening the genotypes for responses to stress environment in green gram. Safavi *et. al.,* (2015) in sunflower, Uday *et. al.,* (2016) in chickpea, Bennani *et. al.,* (2016) and Bennani *et. al.,* (2017) in bread wheat and Susmitha and Ramesh (2020) in dolichos bean, have also suggested the use of these indices for discriminating the test genotypes for their responses to stress environment. These results suggest any one or the combination of these indices could be used to select stress tolerant genotypes. Several researchers have used this criterion and identified some of the indices like MP, GMP and STI as most desirable indices for selection of drought tolerant genotypes in different crops. To illustrate a few, Moosavi *et. al.,* (2008) and Seyyed *et. al.,* (2014) in soybean, Bennani *et. al.,* (2016) and Bennani *et. al.,* (2017) in wheat have reported the utility of MP and GMP for selection of drought tolerant genotypes.

Genotypes selected based on combination of the indices are characterized by drought stress tolerance with high yield under both stress and non-stress (Thiry *et. al.,* 2016).

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