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Evaluation of selection indices for improving terminal heat tolerance in greengram (*Vignaradiata* L. Wilczek)

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ABSTRACT

An investigation was carried out with forty greengram genotypes including one check Samrat during summer 2015 to find out suitable selection indices for influencing the performance of genotypes under heat stress. Seed yield showed positive and significant association with days to maturity (DM), growing degree days (GDD), relative temperature depression (RTD) and heat use efficiency (HUE). Stepwise regression analysis showed that maximum contribution was made by HUE followed by photo-thermal index (PTI) and DM. This indicated that HUE might be utilized as primary key factor, whereas PTI, DM and RTD might be utilized as secondary key factor for improving heat tolerance in greengram. The comparison of different functions revealed that among the single character selection index HUE (index IV) was the key component to construct selection index for terminal heat tolerance in greengram. Beside this DM, PTI, RTD, HUE and seed yield per plant (SYP) (index XV) should be simultaneously selected to achieve maximum gain and improve the heat tolerance in greengram.

Key words: Correlation, discriminant function, greengram, regression, relative efficiency, terminal heat.

Greengram is a short duration crop and grown over wide range of environments in India. It is the main crop of *kharif* but now a day farmers are frequently adopted this crop in *zaid* season due to its short duration and well fitted in wheat-rice cropping system. But this crop is highly affected by high temperature in *Zaid* season. Now the days temperature is rising day by day, which highly affect the crop at different phenophases, ultimately yield. It causes cell death, burning, flower drop, pollen abortion, shortening the grain filling duration etc. (Khalil *et al.,* 2009). Thus there is dire need to develop the heat tolerant varieties in this challenging era. Several agro-meterological indices *viz.,* growing degree days (GDD), photo-thermal unit (PTU), helio-thermal unit (HTU), photo-thermal index (PTI) and heat use efficiency (HUE) have frequently been used as a weather based parameters for assessing crop phenology. Girijesh *et al.* (2011) also used agro-meteorological indices to discriminate the heat tolerant lines. All growth and developmental stages of crop estimated more accurately on the basis of GDD (Warthington and Hatchinson, 2005). For improvement of seed yield, component breeding is important and selection based on multiple characters is more beneficial to achieve desire objectives. The theory of selection indices is based on the concept of manipulating several attributes simultaneously (Smith 1936, Hazel1943, Brim *et. al.* 1959, Singh and Bellman 1974) and has definitely proved advantageous over the selection for individual characters (Hazel and Lush 1942). This would probably be much more effective than any other system of selection approaches involving either level of culling or arbitrary choice in the genetic improvement of complex characters or group of characters. Keeping the above facts under consideration the present investigation was done to discriminate and utilize the suitable indices/character combination and genotypes for improving terminal heat tolerance.

MATERIALS AND METHODS

The experimental material for the present investigation comprised of forty genotypes of greengram including released varieties, advanced lines and local land races. The experiment was laid in randomized complete block design (RCBD) with three replications at the Research Farm, Department of Plant Breeding and Genetics, Tirhut College of Agriculture, Dholi, Muzaffarpur, Bihar (25.5^{0}N, 35.4^{0}E, 52.12 m MSL) during Summer, 2015. Each genotype was sown in six rows in plot of 4 m length with 30 x 10 cm plant geometry. Standard agronomic practices and plant protection measures were taken as per schedule to raise healthy crop. A total of four morpho-physiological traits *viz.,* days to maturity (DM), canopy temperature (CT), relative water content (RWC) and seed yield per plant (SYP) and six agro-metrological indices *viz.,* growing degree days (GDD), halio-thermal unit (HTU), photo-thermal unit (PTU), photo-thermal index (PTI), relative temperature depression (RTD) and heat use efficiency (HUE) were recorded. Five characters were selected for computation of discriminant function on the basis of step wise regression analysis.

The weather parameters for crop growing period were obtained from the Agro-metrology Division, Rajendra Agricultural University, Pusa, Samastipur, Bihar. All energy requirement parameters were recorded at physiological maturity as follows:

Growing degree days was computed with 10^0 c as base temperature on the basis of daily mean temperature with the help of following formula: (Eruola *et al*., 2014)

$$GDD = \frac{\sum (Tmax + Tmin)}{2} - T_b$$

Where, T max and T min are daily mean maximum and minimum temperature, T_b is the base temperature.

Photo-thermal unit (PTU) (degree-days hours) was calculated on the basis of GDD and day length with the formula given below: (Eruola *et al*., 2014)

PTU= GDD x Day length

Halio-thermal unit (HTU) (degree-days hours) was calculated on the basis of GDD and sunshine hours by the following formula: (Eruola *et al*., 2014)

HTU = GDD x Duration of sun shine hours

Photo-thermal index (PTI) (degree-days day^{-1}) was calculated using the following equation: (Haider *et al*., 2003)

PTI = GDD/ Growth days

Heat use efficiency (HUE) (kg ha^{-1} degrees-day) was calculated with the help of seed yield.

HUE = Seed yield (kg ha$^{-1)}$/GDD

Relative temperature depression was calculated using the formula: (Eruola *et al*., 2014)

RTD = (Σ Tmax - Tmin) / Tmax

Where, T max and T min are daily mean maximum and minimum temperature

Relative water content (RWC) of the flag leaves was determined using the equation given by Barr and Weatherley (1962):

$$RWC = \frac{F.W - D.W.}{T.W. - D.W.} \times 100$$

Where,

F.W. = Fresh Weight of flag leaf (g)

D.W. = Dry Weight of flag leaf (g)

T.W. = Turgid Weight of flag leaf (g)

For RWC, leaf sample were taken from 6^{th} node from the base.

Canopy temperature was measured using a hand-held infrared thermometer (Talebi, 2011). The data were subjected to statistical analysis using computer package windows 9.1 version

The selection indices were constructed with various character combinations as per method of Smith (1936) and Hezal (1943) using phenotypic and genotypic variances and co-variances.

Relative efficiency (RE) indices were calculated as -

RE = {GA (1)/GA (2)} x 100

Where as

RE = Relative efficiency indices.

GA_1 = Genetic advance through discriminant function

GA_2 = Genetic advance through straight selection

The expected genetic advance from selection indices was computed on the basis of model suggested by Smith (1936). Twenty five selection indices were computed which served as the basis of selection of genotypes on basis of index score (Table 3).

RESULTS AND DISCUSSION

The analysis of variance (Table 1) clearly indicated that, there was highly significant differences among all the traits and agro-meterological indices studied, indicated that there was sufficient variability present among the material studied under heat stress conditions, which could be further utilized in breeding programme.

The correlation coefficients among various morpho-physiological and agro-meterological indices with seed yield per plant under heat stress condition were established and are presented in Table 1.

Table 1: Analysis of variance for various characters of greengram and is correlation with seed yield

Sl.no	Sources of variation	Replication (d.f=2)	Treatment (d.f=39)	(d.f=78) Error	Correlation coofficent with seed yield (SYP)
1	DM	37.70	31.35**	7.37	0.171
2	GDD	30986	28693**	6883	0.163
3	HTU	35806224384	287614933504**	7191881728	0.120
4	PTU	2470334	1847203**	491524	0.138
5	PTI	45.36	55.92**	17.35	0.076
6	RTD	9305881	8422737**	2069984	0.159
7	CT	1.58	4.19*	2.09	0.050
8	RWC	11.85	31.74*	16.22	0.057
9	HUE	0.07	0.11**	0.02	0.0821*
10	SYP	2.08	4.67**	0.69	1.00

* significant at 5%,** significant at 1%

Table 2: Step wise multiple regression coefficient of agro-morphological traits on seed yield of greengram

Regression coefficients	Traits	b ± SE	Significance level	% contribution of the parameters to R^2 values
b1	DM	0.291 ±0.076	**	0.113
b2	PTI	0.139±0.007	**	0.763
b3	RTD	-0.000±0.001	*	0.043
b4	HUE	06.806±0.168	**	0.935
Intercept constant		431.304		
R^2 value			0.937	
Adjusted R^2 value			0.933	

*= P<0.05, **= P<0.01 level of significance, a= slop of regression, b= regression coefficient, SE= standard error

In present investigation, it is evident that SYP showed positive relation with DM, GDD, RTD but it were non-significant. Only HUE found significant in positive direction, indicated that their effective utilization for heat tolerance. DM showed significant and positive association with GDD, HTU, PTU, RTD. GDD showed significant and positive association with HTU, PTU and RTD. HTU showed significant and positive association with PTU, RTD. PTU showed significant and positive association with RTD and significant and negative association with HUE. As these characters are mutually correlated among each other selection of any one of the character will improve the other and ultimately improve the SYP. Several researchers *viz.,* Mohammadi *et al.* (2003)*,* Gul *et al.* (2008), Hakim (2008), Lavanya and Toms (2009), Yimram *et al.* (2009), Zaid *et al.* (2011) and Singh *et al.* (2014) have earlier reported the positive association between these traits. This deviation may be noted due to breeding material and environmental conditions. The positive association between agro-morphological traits and agro-meterological indices indicated that these characters must be considered to enhance their yield potential and selection for terminal heat tolerant genotypes in greengram.

The multiple regression (Table 2) of SYP on various agro-morphological traits and agro-meterological indices studied confirms the result of correlation analysis and short the yield preditors and discriminate most effective parameters/traits. The traits *like,* PTI and HUE recorded with maximum values of R^2. Among the agro-morphological traits and agro-meterological indices studied, six traits/ indices *viz*., DM, PTI, CT and HUE was found significant indicated the effect of these traits/indices on SYP. The stepwise regression analysis showed that 93.3 per cent adjusted R^2 indicated the sufficient variation possessed by these four traits/agro-meterological indices. It was also observed that maximum contribution was made by HUE

Table 3: Selection index, genetic advance and relative efficiency indices for for improvement of grain yield of greengram under heat stress

SL NO	INDEX	SELECTION INDEX	GA_1	GA_2	RE (%)
1	I	DM	0.01	0.72	1.2
2	II	PTI	0.00	0.59	0.4
3	III	RTD	0.53	2.11	25.0
4	IV	HUE	0.01	0.01	84.0*
5	V	SYP	0.17	0.66	26.0
6	VI	DM + PTI	6.25	35.99	17.4
7	VII	DM + RTD	1.37	14.01	9.8
8	VIII	DM + HUE	0.18	4.80	3.8
9	IX	DM + SYP	2.32	7.91	29.3
10	X	DM +PTI +RTD	3.30	37.52	8.8
11	XI	DM + PTI + HUE	10.96	66.80	16.4
12	XII	DM+ PTI + SYP	2.02	9.32	21.7
13	XIII	DM +PTI +RTD + HUE	54.29	122.06	44.5*
14	XIV	DM + PTI + RTD + SYP	7.64	23.55	32.4*
15	XV	DM + PTI +RTD +HUE +SYP	12.15	21.44	56.7*
16	XVI	PTI + RTD	1.05	17.72	5.9
17	XVII	PTI + HUE	0.90	15.98	5.7
18	XVIII	PTI + SYP	5.77	26.34	21.9
19	XIX	PTI + RTD +HUE	3.97	34.54	11.5
20	XX	PTI + RTD + SYP	3.76	12.45	30.2
21	XXI	PTI +RTD+HUE +SYP	14.74	33.34	44.2*
22	XXI	RTD + HUE	0.28	2.14	13.0
23	XXIII	RTD + SYP	6.91	21.67	31.9
24	XXIV	RTD +HUE + SYP	13.95	29.55	47.2*
25	XXV	HUE + SYP	4.72	19.57	24.1

*- Superior indices

followed by PTI and DM. This indicated that HUE might be utilized as primary key factor, whereas PTI, DM and RTD might be utilized as secondary key factor for improving heat tolerance in greengram.

However, these key indices may be utilized in future breeding programme for heat tolerance but several times selection of two or more traits/indices is not effective because of negative effect of deleterious genes. Thus simultaneous selection model may be proven as best for selection of one or more traits/indices effectively. The relative effectiveness of different selection methods will depend on many factors. Selection criterion based on multiple characters would be more effective and could be worthwhile in identifying best performing genotypes. Considering the criterion five major key factors *viz.,* DM, PTI, RTD, HUE, SYP were selected based on the correlation coefficient and step down regression for improving terminal heat tolerance in greengram. Robinson (1951) indicated that relative efficiencies of discriminant function were increased in maize character combination were included in selection index. In present study, a total 25 selection indices along with genetic worth and relative efficiencies are presented in Table 3. In present investigation the relative efficiency of discriminant function was higher over straight selection and ranged from 0.4 (photo thermal index) percent to 84.0 percent (heat use efficiency). When two characters included in selection, the combination including RTD + SYP was most efficient (31.9%) followed by M + SYP (29.3%) and

HUE + SYP (24.1 %). When function was constructed for three characters, the function including RTD + HUE + SYP was most efficient (47.22%) followed by PTI + RTD + SYP (30.2%) and DM + PTI + SYP (21.7%). When four character combination were included in selection then most efficient (44.5%) character was DM + PTI + RTD + HUE followed by PTI + RTD + HUE + SYP(44.2%) and DM + PTI + RTD + SYP (32.4%). When five character combination were included single character combination DM + PTI + RTD + HUE + SYP (56.7%) was obtained. Plant breeder is always interested to have maximum genetic gain with incorporation of minimum characters in selection index. So results of present investigation indicated that among the single character selection index heat use efficiency (index V) was the key component to construct selection index for terminal heat tolerance in greengram. In character combination for increased seed yield maturity, photo thermal index, relative temperature depression and heat use efficiency along with seed yield (index XV) might be considered to develop a novel plant type for terminal heat tolerance in greengram lines. This also indicated that HUE was found more effective than rest all indices but may also taken under consideration using simultaneous selection method.

Based on above discussion it was noticed that HUE might be utilized as heat index for discriminating heat tolerant genotypes. Besides this index XIII (M + PTI + RTD + HUE) index XIV (M + PTI + RTD + SY) and index XV (M + PTI + RTD + HUE + SYP) were also found superior for the simultaneous selection. Selection of diverse genotypes from these indices may also be added in crossing programme to throw/recover good recombinants by improving **simultaneous traits.** Singh *et al.* (2013) in rice, Singh *et al.* (2014) in mungbean also gave the emphasis on grouping and selection of genotypes based on selection score to get higher genetic gain. Thus, the parents with both high and moderate diversity can be included in breeding programme to isolate the good recombinants. Several researchers gave more emphasis on involvement of diverse parents in crossing program for high heterotic response as well as transgressive segregants in early segregating generations for high seed yield and other targeted trait(s). Katiyar *et al.* (2009), Narasimhulu *et al.* (2013a) also suggested that use of diverse parents gives better chance to develop the superior varieties. Behl *et al.* (1985) suggested that the incensement in heterosis occurs within a restricted range of diversity. Shukla and Singh (2006), Yadav *et al.* (2007) observed that negative association between between F_1 performance and genetic distance (except some traits). Parameshwarappa *et al.* (2009) suggested that moderate genetic diversity is expected to throw heterotic hybrids.

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