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Selection indices and discriminant function analysis for grain yield in greengram [*Vigna radiata* (L.) Wilczek]

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ABSTRACT

Ninety mutants of greengram were taken as experiment materials for estimation of selection indices among the yield components and their direct and indirect effects on grain yield based on Smith-Hazel indices. In the case of mutants of Sujata, 6.29 % higher genetic gain was observed through SC-II (multiple criteria selection) over genetic gain availed in SC-I (yield *per se*) while, in case of mutants of OBGG-52, 5.12 % more genetic gain was availed through SC-II multiple criteria selection) than the genetic gain availed from SC-I (yield *per se*). The highest genetic advance in grain yield per plant was obtained on a linear combination of traits such as days to 50% flowering, pod length, pods per plant, 100-seed wt; grains per pod and yield per plant suggesting that the above characters could be advantageously exploited in the greengram breeding programs. Using yield *per se* performance and index scores based on multiple character selection criteria, twenty productive mutants of these two varieties were selected which are considered to be significantly superior mutant genotype.

Key words: Discriminant function, greengram, mutant, selection indices, seed yield

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is an annual self-pollinated pulse legume. India is the largest producer with more than 50% of world production but the productivity is still very low i.e. 499 kg ha^{-1} in India (Anon., 2016) as compared to countries like China where the productivity is 1276 kg ha^{-1} (Anon., 2015). The bottlenecks in its improvement have been the lack of variability in different traits and improvement of one trait on its own will affect the performance of other traits because of genotypic correlations between traits. Direct selection based on *per se* yield is often not effective in the identification of productive lines as yield is a polygenic controlled complex trait of moderate to low heritability having non-additive gene action and also dependent on several component traits. Selection indices function like an additional characters which are a result of the combination of various characteristics from which selection responses are desired (Santos et al., 2007), which allows the improvement of various characters simultaneously, independently of the existence or not of a correlation between them (Smith, 1936; Hazel, 1943; Williams, 1962; Cruz and Regazzi, 2001). Selection indices have been used in numerous studies to determine the most valuable genotypes as well as the most suitable combination of traits with the intention of indirectly improving the yield in different plants (Siahpoosh et al., 2001; Singh and Balyan, 2003; Chandra et al., 2003; Rabiei et al., 2004; Sabouri et al., 2008; Rezaei and Yousefi , 2008; Imani et al., 2009; Fotokian and Agahi, 2014). Therefore, the use of discriminant function of Fisher (1936) for plant selection was proposed by Smith (1936) to construct a selection index i.e. a linear combination of plant characters associated with the yield which can measure the efficiency of various character combinations and better exploit of genetic correlations with several traits for improvement of the dependent variable i.e. seed yield. The index is a linear weighted function of observations of an individual or its relatives that aim to rank the population for breeding values and thus expected progeny performance (Falconer, 1981). In the present study, yield and multiple character selection index criteria involving direct and indirect components of yield were used for the identification of productive mutant genotype and estimate the expected genetic advance and relative efficiency.

MATERIALS AND METHODS

Two experiments i.e. first experiment consists forty five mutants of a hybrid variety (Sujata) and other experiment consists forty five mutants of a mutant variety (OBGG-52) conducted separately to find out the selection indices and the genetic gain in greengram. these mutants are developed by treating the seed samples of two greengram varieties, viz., Sujata and OBGG-52 with different doses concentrations^{-1} of one physical mutagen (gamma rays), three chemical mutagens (EMS, NG, MH) and combinations of physical and chemical mutagens with a selection of plants for advancing generations from M_1 to M_5 on yield and yield attributes. The single mutagenic treatments were 20 kR, 40 kR, 60 kR gamma-ray; 0.2 %, 0.4 %, 0.6 % EMS; 0.005 %, 0.010 %, 0.015 % NG and 0.01 %, 0.02 %, 0.03 % MH. The three combined treatments were 40 kR gamma rays combined with 0.4 % EMS, 0.010 % NG and 0.02 % MH.

In M_5 generations, forty five mutants of each variety were grown along with the parent variety in randomized block design with three replications at Orissa University of Agriculture and Technology, Bhubaneswar for the study of selection indices and nine characters i.e. Days to 50% flowering, Days to maturity, Plant height, Clusters per plant, Pods per plant, Pod length, Seeds per pod, 100-seed weight and Yield per plant. Basing on these data selection indices were constructed as follows

Construction of selection indices

The genotypic and phenotypic variance and co-variances among the characters provide the basis for constructing selection indices. The selection indices are in the form.

I = b1x1+ b2x2 ……………. + bnxn

where the x’s are the phenotypic value of the n-characters included in the index construction, the b’s are the relative weights to be assigned to each character for computing the index value and I is the index value of each entry on which selection is to be based. The b values are so estimated as to maximize expected genetic advance in the ultimate economic criterion from selection among the materials.

In the present investigation, seed yield is considered as the ultimate economic criterion and thus, appropriate values of b’s would maximize expected genetic advance in yield from index selection obtained by synthesis of the following simultaneous equations as shown by Smith (1963) and Hazel (1943).

b1p1.1 + b2p1.2 + ….. bn p1.n = G1.y

b1p2.1 + b2p2.2 + ….. bn p2.n = G2.y

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b1pn.1 + b2pn.2 + ….. bn pn.n = Gn.y

The P symbols in the above equations represent phenotypic variance co-variance^{-1} among characters and the ‘G’ represents the genotypic co-variance between any particular character and yield.

The selection criteria (SC) applied for the identification of productive mutant cultures were SC-I Direct selection based on yield *per se* (X9) and SC-II Combined direct and indirect selection based on yield (X9) and eight yield influencing traits (X1, X2, X3, X4, X5, X6, X7, and X8). Where, X1–Days to 50% flowering, X2 – Days to maturity, X3 – Plant height, X4 – Clusters per plant, X5 – Pods per plant, X6 – Pod length, X7 – Seeds per pod, X8 – 100-seed weight, X9 – Yield per plant

RESULTS AND DISCUSSION

The analysis of variance revealed a significant genotype effect for all the traits under study. This provides evidence of the presence of sufficient genetic variability among parents and mutants that can be exploited in a breeding program through selection. The estimates of means for different characters of the mutant cultures of both varieties Sujata and OBGG-52 are presented in Tables 1 and 2, respectively. In both cases, none of the mutants flowered significantly earlier than the parent variety. However, twenty-two mutants of Sujata and six mutants of OBGG-52 flowered significantly late than their respective parents. In Sujata, 14 mutants were significantly taller and only one was significantly shorter in height than the parent. In OBGG-52, three mutant cultures were significantly taller and five were significantly shorter in height than the parent. In both cases, none of the mutant cultures showed significantly higher clusters per plant. Seven mutants derived from the variety Sujata showed a significant increase in pods per plant. In the case of OBGG-52, four mutant cultures exhibited a significant increase in pods per plant. Seven mutant cultures of each showed a significant increase in pod length than their respective parent variety. The mutants of these two varieties differed significantly in seeds per pod. Numbers of mutant cultures showing significantly higher seeds per pod than respective parents were three in the case of Sujata and twelve in the case of OBGG-52. Nineteen mutant cultures of Sujata recorded significantly higher 100-seed weight than its parent while in the case of OBGG-52, only one found.

Table 1. Means and selection indices for quantitative traits in the mutants of Sujata variety

Entry No.	Name of mutants	Days to 50% flowering	Days to maturity	Plant height (cm)	Clusters plant^{-1}	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	100-seed weight (g)	Yield plant^{-1} (g)	Selection indices (9 traits)
1	SG1-1	36.0	55.7↓	27.0*	3.47	11.1*	6.50*	9.97	3.03*	3.17*	6.83
2	SG1-2	36.0	55.7↓	27.7*	3.00	10.2	6.33*	9.60	3.05*	2.80*	6.71
3	SG1-3	37.0	56.0	26.9*	3.23	10.7*	6.00	8.87	2.72	2.45	6.50
4	SG2-1	37.7	56.3	26.8*	3.03	8.8	5.97	8.57	3.01*	2.21	6.34
5	SG2-2	37.7	56.7	24.8	2.60	7.3	5.63	9.13	3.19*	2.02	6.19
6	SG2-3	37.3	56.3	27.0*	2.97	8.6	5.83	9.63	3.22*	2.13	6.43
7	SG3-1	38.7*	58.3	26.1	3.17	8.7	6.13	9.53	2.58	2.24	6.28
8	SG3-2	39.3*	58.3	26.8*	3.23	9.1	5.97	9.37	2.68	2.32	6.36
9	SG3-3	38.3	57.3	26.6*	3.17	10.6	6.33*	10.67*	2.75	3.02*	6.85
10	SE1-1	38.0	57.3	27.2*	3.37	9.9	5.90	9.10	2.74	2.54	6.39
11	SE1-2	38.3	57.0	26.3*	3.20	11.2*	6.20*	10.43*	3.19*	3.18*	7.08
12	SE1-3	38.7*	57.3	26.5*	3.03	9.3	5.70	9.63	3.07*	2.46	6.53
13	SE2-1	39.0*	57.0	24.8	2.97	8.8	5.50	9.47	2.70	2.33	6.25
14	SE2-2	39.0*	57.3	24.8	3.30	9.9	6.07	10.03	3.00*	2.83*	6.68
15	SE2-3	38.7*	57.3	27.0*	3.37	9.9	6.30*	10.17	3.22*	2.96*	6.84
16	SE3-1	37.0	57.3	27.1*	3.47	9.4	5.83	8.80	2.95*	2.28	6.24
17	SE3-2	37.3	55.7↓	28.1*	3.43	10.9*	6.43*	10.33*	3.04*	3.27*	6.93

Entry No.	Name of mutants	Days to 50% flowering	Days to maturity	Plant height (cm)	Clusters plant^{-1}	Pods plant^{-1}	Pod length (cm)	Seeds pod^{-1}	100-seed weight (g)	Yield plant^{-1} (g)	Selection indices (9 traits)
18	SE3-3	37.3	55.7↓	26.0	3.17	9.2	5.83	9.27	2.99*	2.31	6.37
19	SN1-1	38.3	56.3	22.6	2.93	8.5	5.97	9.03	2.73	2.13	6.25
20	SN1-2	38.7*	57.7	24.0	3.27	11.5*	6.07	10.00	2.95*	3.37*	6.95
21	SN1-3	39.0*	56.3	23.6	3.07	8.0	5.63	8.40	2.49	1.64	5.92
22	SN2-1	38.3	57.7	26.2	3.00	9.1	5.77	9.20	3.05*	2.37	6.44
23	SN2-2	37.7	56.0	27.5*	3.17	9.9	5.23	8.40	2.71	2.43	6.18
24	SN2-3	38.7*	57.3	24.5	3.03	9.4	5.27	8.87	3.08*	2.40	6.36
25	SN3-1	39.3*	57.7	25.1	3.13	10.1	5.53	9.10	2.81	2.67	6.48
26	SN3-2	39.3*	57.7	25.3	3.10	9.7	5.77	9.23	2.80	2.59	6.49
27	SN3-3	39.7*	57.3	25.9	3.13	10.9*	6.20*	9.93	3.22*	3.05*	7.09
28	SM1-1	39.0*	58.0	24.9	3.17	8.9	5.43	8.70	2.70	2.14	6.11
29	SM1-2	39.3*	59.3*	24.9	3.00	9.4	5.93	9.07	2.73	2.45	6.43
30	SM1-3	39.0*	58.0	25.7	3.27	10.8*	5.80	8.50	3.04*	2.91*	6.68
31	SM2-1	38.3	56.3	24.7	2.83	9.7	5.37	8.07	2.80	2.22	6.28
32	SM2-2	38.7*	57.0	23.6	2.80	9.9	5.87	9.53	2.76	2.45	6.59
33	SM2-3	38.7*	58.0	22.9	2.87	8.8	5.43	8.67	2.71	2.07	6.13
34	SM3-1	39.7*	59.3*	22.9	2.53	7.4	5.27	8.37	2.42	1.91	5.83
35	SM3-2	39.7*	58.7	23.9	2.63	8.1	5.43	8.93	2.41	2.31	6.04
36	SM3-3	40.0*	59.0*	23.5	2.73	7.6	5.57	8.63	2.48	1.85	5.97
37	SGE2-1	38.7*	58.7	22.7	2.57	7.3	5.87	9.47	2.33	1.60	5.95
38	SGE2-2	38.7*	59.0*	17.6↓	2.33	7.9	5.97	9.43	2.55	2.26	6.21
39	SGE2-3	38.3	58.3	23.2	2.93	8.1	5.63	9.23	2.79	2.27	6.11
40	SGN2-1	37.0	57.7	21.9	2.63	7.9	5.77	8.60	2.25	1.50	5.80
41	SGN2-2	37.3	58.3	25.9	2.67	7.2	6.00	8.10	2.29	1.91	5.75
42	SGN2-3	37.3	58.0	25.6	2.20	7.2	5.70	9.07	2.60	2.00	6.00
43	SGM2-1	38.0	58.0	20.5	2.53	7.7	5.33	8.27	2.44	1.52	5.77
44	SGM2-2	37.7	58.3	23.3	2.83	8.3	5.70	9.80	3.17*	2.35	6.36
45	SGM2-3	38.3	57.7	21.8	2.97	8.2	5.77	9.50	3.20*	2.38	6.35
46	Sujata	37.0	57.3	23.0	3.13	8.9	5.67	9.30	2.62	2.12	6.06
	C.D. (5%)	1.36	1.46	3.27	0.57	1.79	0.53	1.03	0.31	0.68	-
	GA	1.439	1.505	3.031	0.326	1.758	0.430	0.853	0.478	0.668	

* Indicates significant increase over control (var. Sujata) at 5 % level.

↓ Indicates significant decrease from control (var. Sujata) at 5 % level.

Grain yield is a polygenic controlled complex character with low to moderate heritability owing to environmental effects and also greatly influenced by many interrelated component traits, which are also mostly polygenic and the direct selection for yield is often not much effective. Thus the use of multiple criteria selection for identification of superior genotypes has been done in several crops by many workers. The use of different types of multiple selection criteria for the identification of productive micromutant lines in different crops has been reported in pulses crops before by Dasgupta et al. (1984), Patel et al. (2007) and Choudhary et al. (2017) . In the present study, instead of selecting M_5 cultures based on yield per plant only, an attempt was made to select high yielding M_5 cultures using multiple character selection indices. The selection was made based on SC-I on basis of yield *per se* and SC II- index based on all nine traits including yield per plant.

Selection indices of each mutant genotype of both varieties for SC-II were calculated using the respective discriminant function which varies from 5.75 to 7.09 in the case of mutants of Sujata (Table 1), whereas 4.59 to 5.74 in the mutants of OBGG-52 (Table 2). To assess the efficiency of the different selection criteria, the expected genetic gain for those criteria was estimated. In the case of Sujata mutant cultures, the expected genetic gain for SC-I (yield *per se*) was 0.668 g per plant while that for the multiple criteria selection through SC-II was 0.710 g plant^{-1} indicating 6.29 % superiority over SC-I. In the case of OBGG-52 cultures, the expected genetic gain for SC-I (yield *per se*) was 0.586 g per plant as against 0.616 g per plant for SC-II indicating 5.12 % superiority over the genetic gain from SC-I. Thus, all the multiple character selection index criteria showed higher expected genetic gain than selection based on yield *per se*. The selection based on the linear combination of yield component characters in the form of selection indices is more advantageous (Fig. 1 and 2) for the improvement of productivity in mungbean which was also earlier reported by Dasgupta and Das (1984), Magnussen (1991) and Lalehzar et al. (2017).

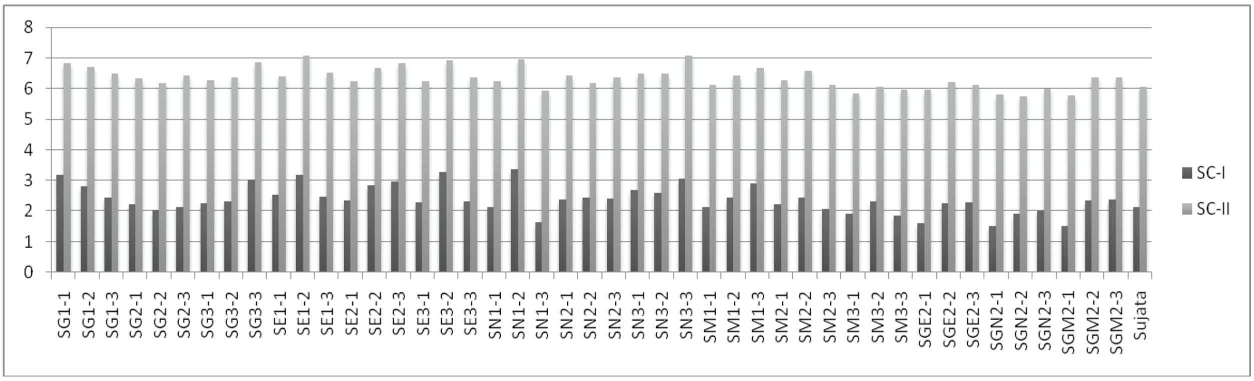

Fig. 1. Selection criteria index for mutants of Sujata

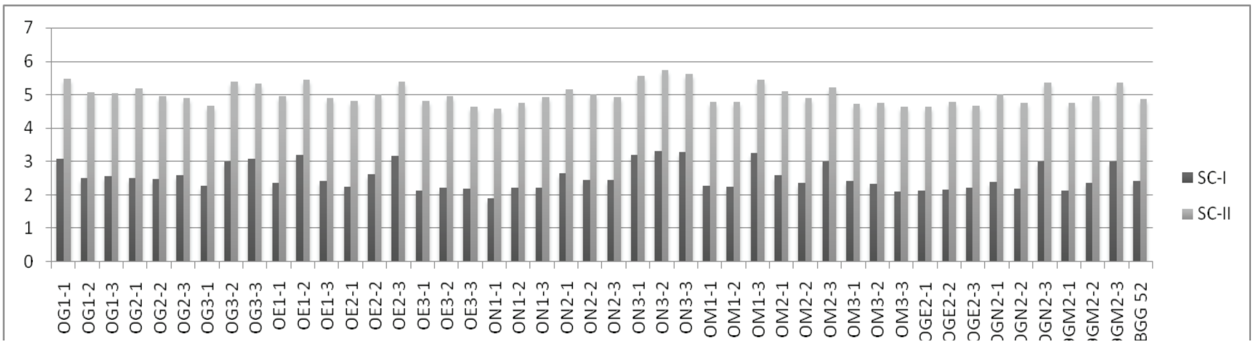

Fig. 2. Selection criteria index for mutants of OBGG-52