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Shete RR
Department of Botany, College of Agriculture, Dhule, Maharashtra, India

Borale SU
Assistant Professor, Department of Botany, College of Agriculture, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra, India

Andhale GR
Department of Botany, College of Agriculture, Dhule, Maharashtra, India

Girase VS
Department of Botany, College of Agriculture, Dhule, Maharashtra, India

Corresponding Author:
Shete RR
Department of Botany, College of Agriculture, Dhule, Maharashtra, India

Screening of soybean genotypes for pod shattering tolerance and association of different traits with seed yield

Shete RR, Borale SU, Andhale GR and Girase VS

Abstract
In wild habitats, pod dehiscence is a critical strategy for seed dispersal; however, in cultivated crops it is one of the major source of yield loss. Therefore indehiscence of pods was likely to be one of the first traits strongly selected in crop domestication. The forty genotypes studied in present investigation showed quite significant differences among themselves for pod shattering tolerance. The average percentage of pod breakage was observed 34 per cent. In terms of pod shattering tolerance, among the 40 genotypes, MACS-1701 (2%), MACS-NRC-1647 (4%), RVSM-2011-10 (8%), AMS-100-39 (10%), DSB-33, MACS-450, KDS-1096 (12%), KDS-344, PS-1670, and KDS-1144 (14%), were found to be highly to moderately tolerant. The strongest correlation at the genotypic and phenotypic level was found between number of pods per plant and seed yield per plant, which was followed by the days to 50 percent flowering and days to maturity. While pod shattering percentage showed positive but non-significant association with seed yield.

Keywords: Soybean genotypes, pod shattering tolerance, traits, seed yield

Introduction
Soybean is significant and widely consumed oil seed crop grown across the globe. It also known as “miracle bean” or “golden bean” due to its wide range of industrial, nutritional and agricultural uses. Soybean have higher nutritional value. It is believed that modern cultivated soybean (*Glycine max*) crop domesticated from wild soybean (*Glycine soja*) in China 6000 to 9000 year ago (Carter *et al*., 2004) [9] latter it spread in neighbouring countries through land and sea routes developed for trading.

Soybean belongs to the family fabaceae (Leguminosae), sub family Fabioideae and genus Glycine. It is a self-pollinated crop and diploid (2n = 40) in nature. Soybean seeds germinate epigeally, and seedlings emerge in 4-5 days under ideal circumstances. It contains approximately 38-42% quality protein and 18-20% oil fortified with vital fatty acids. It also has 35% carbohydrates and 5% minerals. Soybean is known as “poor man’s meat” because of its high protein content and nutritional values. It also includes isoflavones which is beneficial for human health protecting from several diseases such as coronary heart disease, cancer, osteoporosis, diabetes, etc. (Khadar. 2019) [15]. Soybean oil is the second most widely used vegetable oil in the world. It can be used as a raw material in the production of lubricants, adhesives, paints, varnishes, etc. Brazil, USA, Argentina, China and India are the leading countries in the production of soybean all over the world. India ranks 4th in area (12.2 million hectares) and 5th in soybean production (11.20 million metric tons) but on the other hand soybean productivity is much lower in India (882 kg per ha) as compared to other dominant soybean producing countries like Brazil (3564 kg per ha) and USA (3417 kg per ha) (SOPA, 2021). Tropical and subtropical regions have warm and humid climate thus have more production issues including pest, disease, pod cracking and lower seed viability. Pod shattering is one the reason for lower seed yield. Pod dehiscence or shattering mean opening of mature pods along ventral or dorsal sutures and shedding of seeds at the time of maturity or during harvesting (Bhor *et al.*, 2014) [8]. It can be diminished by using resistant or tolerant soybean varieties. Developing a pod shattering tolerant cultivar can increase soybean output and also help in increasing farmer economic profit. Therefore, there is a great scope for a plant breeder to work on crops like soybean for pod shattering tolerance

The current research will enable plant breeder to select pod shattering tolerant genotypes in further crop improvement programs. The tolerant genotypes identified in the current

investigation could be used to create new recombinant strains. It will assist soybean farmers in lowering production losses and allowing crop harvesting to be postponed for two to three weeks in the case of a labour problem.

Materials and Methods

A) Experimental details

The experimental material comprised of 40 soybean genotypes available from Agriculture Research Station, Kasbe Digraj. The field study was carried out at Botany Section farm, college of agriculture, Dhule during kharif 2021. The climate in the region is generally hot and dry with average rainfall of 500mm to 600 mm. Randomized block design was used to conduct experiment with two replications. Each genotype had grown in 4m long row in each replication. The spacing between two row was 45cm and 10cm within a row. The type of soil was black cotton soil. The field was maintained weed free by occasional hoeing and hand weeding. Irrigation given as per the requirement.

B) Recording of Observations

Five randomly chosen plants were observed for twelve features, including days to 50 percent germination, days to 50 percent flowering, days to maturity, plant height, number of primary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight, seed yield per plant, protein content, oil content and pod shattering percentage in each replication.

C) Pod Shattering Tolerance Evaluation

Forty soybean genotypes were tested for pod shattering tolerance by oven dry method (Tiwari and Bhatnagar, 1997) [2]. In this method 20 pods of each variety from a replication were selected at harvesting stage and kept in ceramic bowl at 44 °C for 6 hrs in a hot air oven and further procedure carried out for 7 days regularly. On the seventh day, the number of broken/dehiscence pods were counted and calculated as a percentage. The genotypes were divided in five groups according to the percent pod shattering. The score was given in 1 to 5 scale used by Asian Vegetable Research Development Centre (AVRDC) in soybean [Anonymous, 1979] as follow

Table 1: Scale used for pod shattering Categorization

0%	Very Resistant
1-10%	Resistant
11-25%	Tolerant
26-50%	Moderately Susceptible
>50%	Very Susceptible

Results and Discussion

A) Correlation Analysis

The correlation coefficient is a statistical measure use to determine magnitude and direction of association among two or more variable. The phenotypic correlation coefficient reflects the extent of observed relationship between two traits. It indicates the effect of both heredity and environment on traits and therefore, differ under different environmental conditions and thus does not provide actual genetic map of correlation between traits. On the other hand the genotypic correlation is heritable association between two variables and provide an essential connection between genes controlling two or more characteristics, which is more significant in formulating effective selection program. In the present investigation genotypic correlation coefficients were higher for all characters than that of phenotypic correlation coefficients implying inherent association between different traits, under study and low influence of environmental factors on genotypic expression of correlation.

At both the genotypic and phenotypic levels, traits such as number of pods per plant, 100 seed weight and number of primary branches per plant showed a significant and positive correlation with seed yield per plant. Similar findings reported by Baraskar *et al*. (2015) [5], Painkra *et al*. (2018) [25], and Mahbub and Kumar *et al*. (2020) [31], for number of pods per plant, 100 seed weight. The strongest correlation at the genotypic and phenotypic level was found between number of pods per plant and seed yield per plant which was followed by the days to 50 percent flowering and days to maturity. With the exception of number of seeds per pod, protein content and days to 50 percent germination, almost all variables were positively linked with seed yield per plant. The characters number of pods per plant and 100 seed weight showed strong positive correlation with seed yield per plant it indicate that direct selection based on this trait would help in developing high yielding genotypes. Similar observations were also made by Neelima *et al*. (2017) [24], Kumar *et al*. (2020) [2]. and Pawar *et al*. (2020) [26].

Pod shattering percentage at 44 °C had not showed significant association with any morphological trait in the present investigation. The findings are in concurrence with Barate *et al*. (2018) [6] and Gawhane *et al*. (2022) [12]. In plant breeding, correlation analysis used to measure mutual relationship between various plant characters and determine the component traits on which selection can be based for genetic enhancement of yield and its contributing traits. The information about inter relationship between characters may found useful to plant breeder for conducting efficient plant breeding program

Table 2: Genotypic correlation for twelve characters in forty genotype of soybean

Traits	Days to 50% germination	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/plant	Number of pods /plant	Number of seeds / pod	100 seed weight	Protein content (%)	Oil contents (%)	Pod shattering %	Seed yield /plant
Days to 50% germination	1.00											
Days to 50% flowering	-0.114	1.00										
Days to maturity	-0.193	0.781**	1.00									
Plant height(cm)	-0.096	0.099	0.295**	1.00								
Number of primary branches /plant	0.053	0.175	0.306**	0.352**	1.00							
Number of pods/plant	-0.098	0.19	0.385**	0.337**	0.537**	1.00						
Number of seeds/pod	0.192	-0.045	0.112	-0.197	-0.2	0.361**	1.00					
100 seed weight	-0.005	-0.179	-0.181	-0.031	-0.112	0.065	-0.131	1.00				
Protein content (%)	0.245*	-0.024	-0.094	-0.215	-0.158	-0.218	-0.078	-0.058	1.00			

Oil content (%)	0.117	-0.175	-0.045	-0.021	0.079	0.189	0.145	0.051	0.540**	1.00		
Pod shattering% at 44 ºC	0.094	0.156	0.171	0.148	0.054	0.15	-0.104	-0.011	-0.008	-0.121	1.00	
Seed yield / plant	-0.129	0.036	0.271	0.236	0.444**	0.866**	-0.284	0.550**	-0.157	0.183	0.073	1.00

*,** significant at 1 and 5 percent respectively

Table 3: Grouping of genotypes for pod shattering using 1-5 scale given by AVRDC (1979).

Score	Percentage of pod shattering	Group/ Class	Genotypes
1	0%	Very Resistant	---
2	1-10%	Resistant	MACS-1701, MACS-NRC-1647, RVSM-2011-10, AMS-100-39
3	11-25%	Tolerant	KDS-1096, DSB-33, MACS-450, KDS-344, PS-1670, KDS-1144, MAUS-768, Himso-1691, KSL-441, Superstar-211, DS-3105, JS-9305
4	26-50%	Moderately Susceptible	DS-228, TS 20-5, MAUS-806, RVS-2012-20, DSB-23, DLSB-2, JS-335, NRC-142, KDS-753, KDS-726, NRCSL-1, NRC-142, DSB-21, DLSB-1, VLS-101, NRC-128, PS-1661, MACS-1460
5	>50%	Very Susceptible	AS-15, JS-22-14, ASB-9, DSB-38, RVSM-2012-11, KDS-992, KS-103

D) Pod shattering tolerance

Pod dehiscence or shattering refers to opening of mature pods along ventral or dorsal sutures and shedding of seeds at the time of maturity or during harvesting. Pod shattering is a vital feature of wild species for their propagation and adaptability of progeny under varying environmental and field conditions. However, pod shattering is not a desirable trait in agricultural plants since it makes crop harvesting difficult and often result into greater yield losses. Tolerant or resistant cultivar developed through plant breeding program may found useful to farmers for commercial cultivation. Tolerant genotypes found in the present study can be utilized for development of new recombinant strains in a plant breeding program. It will help soybean growers to reduce yield losses and permit delayed harvesting of crop for two to three week in case of labour crisis. Similar findings are also reported by Bhor *et al.* (2014) [8], and Girase *et al*. (2018) [13], Krishnawati *et al.* (2020 & 2021) [18-19] in soybean cropand Girase *et al*. (2018) [13] and Barate *et al*. (2020) [7] in mungbean

In this investigation the average percentage of pod shattering was 34 percentin a hot air oven method at 44 °C. The trait's values varied from 2 (MACS-1701) to 94 (AS-15) per cent. Among the forty genotype, MACS-1701 (2%), MACS-NRC-1647 (4%), RVSM-2011-10 (8%), AMS-100-39 (10%), DSB-33, MACS-450, KDS-1096 (12%), KDS-344, PS-1670, and KDS-1144 (14%), were found highly to moderately tolerant to pod shattering as the shattering percentage of these genotype is significantly less than the general mean. While genotype *viz*. AS-15 (94%), RVSM-2012-11 (76%), and JS-22-14 (72%) were found more susceptible to pod shattering. While screening germplasm of soybean for pod shattering tolerance, four genotypes were found resistant, twelve genotypes were tolerant, seventeen genotypes were moderately susceptible and eight genotypes were very susceptible as shown in Table No 3. The twenty three genotype showed significantly less shattering than the average percentage of pod shattering.

Conclusion

The characters such as number of pods per plant, 100 seed weight, number of primary branches per plant, days to maturity, and plant height showed significant and positive genotypic correlation with seed yield per plant. Number of seeds per pod had negative and significant effect on seed yield, while characters such as protein content and days to 50 percent germination were negatively but non significantly associated with seed yield per plant. Direct selection of the characters having positive significant effect on seed yield would help in developing high yielding genotypes. Pod shattering percentage had not showed any significant association with the morphological and biochemical traits studied in present investigation but the tolerant genotypes found in present study such as MACS-1701, MACS-NRC-1647, RVSM-2011-10, AMS-100-39, DSB-33, MACS-450, KDS-1096, KDS-344, PS-1670, and KDS-1144 could be used as donor parent for producing pod shattering resistant or tolerant genotype in future breeding program or directly used as a variety upon selection.

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