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Correlation of Yield and Associated with other Characters in Pod Shattering Soybean (*Glycine max* (L.) Merrill.)

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Abstract: *In present investigation Correlation of pod shattering for yield and associated with other related characters in soybean (*Glycine max *(L.) Merrill.) Among the four parents, MACS-450 and DS-9712 pod shattering tolerant while Monetta and Kalitur pod shattering susceptible were get three cross combination* viz., *Monetta × MACS-450, Kalitur × DS-9712 and Kalitur × MACS-450. As per association and correlation coefficient analyses that positive and significantly correlation with for all the three crosses at 40R"C and 80R"C pod shattering in soybean, number of cluster per plant and pod length. The genotype having the small pod having less seeds were tolerant to pod shattering, whereas, pod wall thickness, No. of pods per cluster and 100 seed weight were found to be significantly negative correlated with the degree of pod shattering. Pod wall thickness was found to be important in resistance to pod shattering in this study and could be potentially serve as criteria for the selection of resistance to this phenomenon. The finding that association between pod shattering and pod wall thickness was found that to be negative and highly significant suggested that, Thicker the pod wall lesser the pod shattering. Identified that trait of the pod and enlargement of this feature provides the structural basis of resistance to pod shattering in soybean.*

Keywords*: Correlation, pod shattering, pod wall thickness, Soybean.*

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] cultivation is rapidly expanding partly due to its high nutritional value as food for both humans and livestock and as an important industrial crop. It is considered as a "Golden bean" due to its dual qualities *viz.*, high protein (40%) and oil (18 to 20%) content. India is the fourth largest producer of soybean in the world. However, India's share in world production of soybean is only 5%. On an average Madhya Pradesh and Maharashtra produce 51 and 33 per cent of total production of soybean respectively.

Pod shattering is the opening of pods along both the dorsal and ventral sutures of the soybean pod. Fully mature pods of soybean are extremely sensitive to opening, resulting in seed dehiscence. Though this trait is important for the adaptation of the wild species to natural environments as a mechanism for seed dispersal, it leads to a significant yield loss in soybean production, if found in cultivated forms. This can take place in susceptible varieties prior to harvest due to disturbance of the canopy by wind or during harvesting as the harvesting equipment moves through the crop during dry weather conditions, leading to seed losses of 50-100% (IITA, 1986).

This loss of seed not only has a drastic effect on yield but also results in the emergence of the

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soybean as a weed in the subsequent growing season. Pod shattering trait in soybean can be controlled by several strategies. It may also be possible to achieve this by increasing the size or number of vascular strands within the dehiscence zone, increasing the area of the dehiscence zone or modifying pod wall thickness to reduce the mechanical effects of desiccation (Morgan *et al.*, 1998). Among the available control options, genetic improvement, by introducing resistance genes from related species into susceptible cultivars is usually more effective, less costly, not subject to environmental conditions and easier for growers to implement. However, this is both time consuming and laborious. The hybridization strategy also has to cope with transferring two or more genes, which are recessive in action into each of the breeding lines. Indeed, different genetic backgrounds have revealed different number of genes to be important in shattering resistance in soybean (Caviness, 1963; Carpenter and Fehr, 1986; Tukamuhabwa *et al,* 2000). These difficulties have been compounded by the fact that shattering is a difficult and time-consuming trait to assess in the field because field assessments, based on visual observation and handling, are subjective and depend greatly on the maturity and moisture state of the crop (Morgan *et al.*1998).

Pod shattering in soybean is a field problem which could lead to serious yield losses if care is not taken. Pod shattering behaviour of soybean variety is found to be associated with other agronomic characteristics. The knowledge of inheritance of pod shattering provides useful tool for selection of suitable parents and segregating populations for developing shattering tolerance progeny which is also challenging task to breeder due to complex nature of inheritance of the character.

MATERIALS AND METHODS

The present investigation was conducted at Post Graduate Institute, Botany Research Farm, MPKV, Rahuri during the period from 2013-2014 and 2014-2015. On the basis of susceptibility and tolerant to pod shattering of soybean four genotypes were selected for present investigation. Among the four parents, two MACS-450 and DS-9712 pod shattering tolerant while Monetta and Kalitur (pod shattering susceptible) were get three cross combination. Three cross combinations for pod shattering traits *viz.,* Monetta × MACS-450 (S×R); Kalitur × DS-9712 (S×R) and Kalitur × MACS-450 (S×R) were conducted in *Kharif* 2013 to produce the F_1 seeds. F_1s sown and F_2s seeds were made as well as backcrosses, B_1s and B_2s of three crosses were also made in early *summer 2014*.

The experiment was laid out in randomized block design (RBD) with three replications in *Kharif* 2014. The experimental material consisted of 18 treatments consisting of 6 parents, 3F_1s, 3F_2s, 3B_1s and 3B2s, of three crosses (Monetta × MACS-450, Kalitur × DS-9712 and Kalitur × MACS-450). The parents, F_1s, F_2s, and back crosses were randomized separately in each of the three replications. Sowing was done in rows of 3 m length and having 45 x 10 cm distance in a row to plant (productive soil). One row was assigned to P_1s, P_2s, F_1s, while the two rows to each of the B_1s and B_2s and 10 rows to F_2s. This has permitted for raising of 30 plants in each of P_1s, P_2s, F_1s, 60 plants in B_1s and B_2s, and 300 plants in each of the F_2s, in each of the three replication for each cross. Fertilizer dose of 50 kg N and 75 Kg P_2O_5/ ha for irrigated situation was applied at the time of sowing. The experiment was sown on 7th of July 2013. All inter-culturing operations were carried out regularly as per need and stage of crop growth.

Pod shattering screening was done under the lab condition as per oven dry method reported by Tiwari and Bhatnagar (1997) with little modification. The properly harvested 20 pods each of P_1s, P_2s, F_1s, F_2s, B_1s and B_2s generations were kept in brown paper bags at room temperature for 15 days to equalize the moisture content of all pods. Then the bags were kept in Hot air oven for 40R"C (6 hrs. in a day and ambient temperature at night) for 7 days. Percentage of shattering were recorded when more than 70% pods of susceptible parents were shattered and number of shattered pods were counted and expressed in percentage as below,

$$\text{Pod shattering percentage (\%)} = \frac{\text{Number of pods shattered}}{\text{Total number of pods}} \times 100$$

Percentage of pod shattering induced was recorded and determined according to 1-5 scale used by AVRDC (1979). The scoring was done by (AVRDC) Asian Vegetable Research Development Centre in 1 to 5 scale 1=0%, 2=1-10%, 3=11-25%, 4=26-50% and 5=>50% where, Very Resistant, Resistant, Moderately resistant/tolerant, Moderately Susceptible and Very Susceptible, respectively. Whereas, scored in 0-10 scales used by Bailey *et al.* (1997), where, 0 < 1% = 0, 1-10% =1, 11-20% = 2, 21-30%=3, 31-40% = 4, 41-50% = 5, 51-60%=6, 61-70%=7, 71-80 = 8, 81-90%=9, 91-100%=10. Based on the scale (1-3 scale) of Bailey *et al.* (1997), Mohammed (2010) and Bhor *et al.* (2014) phenotypic classes were assigned as follows: progenies with the score of 1 were regarded as resistant, progenies with score of 2 as intermediate and 3 as susceptible.

RESULT AND DISCUSSION

Correlation studies are important in plant breeding, as Sir Francis Galton (1988) emphasized the use of this index to describe the degree of association between two or more traits. It gives the total mutual relationship between two traits. When two variables change together in such a way that an increase in one variable is accompanied by an increase in the other, the variables are said to be positively correlated. In biological measurements, the relationship between the two variables is not likely to be as complete as this, but it is obvious that certain characters may be expected to show a strong correlation. Should an increase in one variable go hand in with a decrease in the other, these two variables are said to be negatively correlated. If there is no relationship between two variables, they are said to be independent or uncorrelated. Simple correlation analysis among the characters has been presented in Table 1, 2 and 3.

Cross I: (MACS-450 × Monetta)

The perusal of result revealed that days to first flowering was positively and significantly correlated with days to 50 % flowering (0.700) followed by pod wall thickness (0.651) and days to maturity (0.578). The days to 1st flowering was negatively and significantly correlated with pod shattering at 40°C (-0.729) and pod shattering at 80°C (-0.684). Days to 50% flowering was positively and significantly correlated with days to maturity (845) and pod wall thickness (0.816) whereas, negatively and significantly correlated with pod shattering at 40°C (-0.936) and pod shattering at 80°C (-0.947) followed by No. of cluster per plant (-0.727) pod length (-0.484). The days to physiological maturity was positively significant with pod wall thickness (0.683) while, negatively and significantly correlated with pod shattering at 40°C (-0.816) and pod shattering at 80°C (-0.861) and No. of cluster/plant (-0.474)

The number of pods/plant is positively and significantly correlated with yield per plant (0.969) followed by 100 seed weight (0.737), No. of seeds/pod (0.601), and pod wall thickness (0.598). The clusters/plant was positively significant with pod shattering at 40°C (0.613) and pod shattering at 80°C (0.635) followed by pod length (0.503) whereas, number of pods/cluster (-0.479) and pod wall thickness (-0.556) were negatively significantly correlated with clusters/plant. The no. of seeds/pod had positive and significantly correlated with 100 seeds weight (0.666) and yield per plant (0.517). The test weight is positively significantly with yield/plant (0.630) and pod wall thickness (0.587).

The yield/plant was positively significant with pod wall thickness (0.626) yield per plant while, it was negatively and significantly correlated with pod shattering at 40°C (-0.482) and pod shattering at 80°C (-0.504). Pod wall thickness was negative and highly significant with pod shattering at 40°C (-0.932) and pod shattering at 80°C (-0.910). The pod shattering percentage at 40°C was positively and highly significant with pod shattering at 80°C (0.969) (Table 1).

Cross II: (DS-9712 × Kalitur)

The perusal of result revealed that days to first flowering was positively and significantly correlated with days to 50 % flowering (0.961) followed by days to maturity (0.534). The 100 seed weight was negatively and significantly correlated with (-0.736). Days to 50% flowering was positively and significantly correlated with days to maturity (0.514) whereas, it had negative and significantly

Table 1.
Phenotypic correlation analysis between pod shattering percentage at 40R°C and associated with other seed related traits in Cross-I (MACS-450 × Monetta).

Traits	*Days to 1st flowering*	*Days to 50% flowering*	*Days to maturity*	*No. of pod/ plant*	*No. of cluster/ plant*	*No. of pods/ cluster*	*No. of seeds/ pod*	*100 Seed wt.*	*Yield/ plant*	*Pod wall thickness (mm)*	*Pod length (cm)*	*PD% at 40°C*	*PD% at 80°C*
Days to 1st flowering	**1.000**	0.700**	0.578*	0.045	-0.362	0.169	0.168	0.314	0.065	0.651**	-0.240	-0.729**	-0.684**
Days to 50 % flowering		**1.000**	0.845**	0.172	-0.727**	0.171	-0.170	0.173	0.276	0.816**	-0.484*	-0.936**	-0.947**
Days to maturity			**1.000**	0.311	-0.474*	-0.265	0.090	0.175	0.426	0.683**	-0.165	-0.816**	-0.861**
No. of Pods/Plant				**1.000**	0.112	-0.022	0.601**	0.737**	0.969**	0.598**	-0.061	-0.423	-0.426
No. of Clusters/Plant					**1.000**	-0.479*	0.437	0.017	0.086	-0.556*	0.503*	0.613**	0.635**
No. of Pods/Cluster						**1.000**	-0.216	0.252	-0.082	0.295	-0.458	-0.214	-0.173
No. of seeds / pod							**1.000**	0.666**	0.517*	0.242	0.244	-0.075	-0.061
100 seed weight								**1.000**	0.630**	0.587*	-0.062	-0.416	-0.368
Yield / plant									**1.000**	0.626**	-0.091	-0.482*	-0.504*
Pod wallthickness (mm)										**1.000**	-0.428	-0.932**	-0.910**
Pod length(cm)											**1.000**	0.487*	0.450
PD % at 40°C												**1.000**	0.969**
PD % at 80°C													**1.000**

*Significant at 5 % (0.468) and ** Significant at 1 % (0.590)

correlation with no. pod/cluster (-0.739) and 100 seed weight (-0.678). The days to maturity was positively significant with pod shattering at 40°C (0.889) and pod shattering at 80°C (0.861) followed by No. of cluster/plant (0.837), pod length (0.656), No. of pod/plant (0.596), yield per plant (0.586), No. of seeds/pod (0.477), Whereas, pod wall thickness (-0.876), No. of pods/cluster (-0.698), 100 seed weight (-0.642) had negatively significant correlation with maturity.

The number of pods/plant is positively and significantly correlated with yield per plant (0.976) followed by No. of cluster/plant (0.930), pod shattering at 40°C with a (0.882) and pod shattering at 80°C (0.877), length (0.678) and No. seeds/pod (0.588). Whereas, pod wall thickness (-0.703) was negatively significant. The clusters/plant was positively significant with pod shattering at 40°C (0.975) and pod shattering at 80°C (0.958) followed by followed by yield/plant (0.918), pod length (0.738) and No. seeds/pod pod (0.574). Whereas, pod wall thickness (-0.830) was negatively and significantly correlated with clusters/plant.

Number of pods per cluster was positively significant with 100 seed weight (0.776) and pod wall thickness (0.532). The no. of seeds/pod was positive and significant correlated with pod length (0.776) followed by pod shattering at 40°C (0.600) and pod shattering at 80°C (0.647), yield per plant (0.600). While, pod wall thickness (-0.627) was negatively significant for seeds per pod. The yield/plant was positively and significantly correlated with pod shattering at 40°C (0.870) and pod shattering at 80°C (0.879) and pod length (0.670). While pod wall thickness (-0.694) was negatively significant with yield per plant.

Pod wall thickness was negatively highly significant correlation with pod shattering at 40°C (-0.908) and pod shattering at 80°C (-0.898) followed by pod length (-0.726). However, for pod length was positively and significantly correlation with pod shattering at 40°C (0.736) and pod shattering at 80°C (0.725). The pod shattering percentage at 40°C was positively and highly significant with pod shattering at 80°C (0.980) (Table 2).

Cross III: (MACS-450 × Kalitur)

The phenotypic correlation between pod shattering result revealed that days to first flowering was positively and significantly correlated with days to 50 % flowering (0.884) followed by pod wall thickness (0.719) and 100 seed wt. (0.598). The days to 1st flowering was negatively and significantly correlated with days to maturity (-0.732) followed by pod shattering at 40°C (-0.687) and pod shattering at 80°C (-0.656), yield/plant (-0.676), No. of cluster/plant (-0.558) and No. of pod/plant (-0.476). Days to 50% flowering was positively and significantly correlated with pod wall thickness (0.707) and 100 seed weight (0.581) whereas, negatively and significantly correlated with pod shattering at 40°C (-0.851) and pod shattering at 80°C (-0.847) followed by days to maturity (-0.808), No. of cluster/plant (-0.791), yield/plant (-0.786), No. of pods/plant (-0.702), No. of seeds/pod (-0.523). The days to physiological maturity was positively significant with pod shattering at 40°C (0.816) and pod shattering at 80°C (0.780) followed by No. of cluster/plant (0.577), No. of seeds/pod (0.562), No. of pods/plant (0.481), yield/plant (0.481), whereas, negatively and significantly correlated with pod wall thickness (-0.870), 100 seed weight (-0.664) and No. of pods/cluster (-0.474).

The number of pods/plant is positively and significantly correlated with No. of cluster/plant (0.978) followed by pod shattering at 40°C (0.849) and pod shattering at 80°C (0.887), yield/plant (0.780) and pod length (0.571).

The clusters/plant was positively significant with pod shattering at 40°C (0.908) and pod shattering at 80°C (0.934) followed by yield/plant (0.790), pod length (0.530) whereas, pod wall thickness (-0.556) was negatively significant correlated with clusters/plant. The no. of pods per cluster positive and significantly correction with 100 seed weight (0.599) while, negatively significant in no. of seeds per pod (-0.471). The number of seeds/pod positive and significantly correlated with pod shattering at 40°C (0.468) and pod shattering at 80°C (0.573). Whereas, negatively significantly with pod wall thickness (-0.642). Test weight was negatively significant with pod shattering at 40°C (-0.528).

Table 2
Phenotypic correlation analysis between pod shattering percentage at 40°C and associated with other seed related traits in Cross-II (DS-9712 × Kalitur).

Traits	*Days to 1st flowering*	*Days to 50% flowering*	*Days to maturity*	*No. of pod/ plant*	*No. of cluster/ Plant*	*No. of pods/ cluster*	*No. of seeds/ pod*	*100 Seed wt.*	*Yield/ plant*	*Pod wall thickness (mm)*	*Pod length (cm)*	*PD% at 40°C*	*PD% at 80°C*
Days to 1st flowering	1.000	0.961**	0.534*	-0.168	0.101	-0.744	-0.087	-0.736**	-0.207	-0.219	0.129	0.203	0.155
Days to 50 % flowering		1.000	0.514*	-0.192	0.072	-0.739**	-0.091	-0.678**	-0.215	-0.215	0.069	0.184	0.159
Days to maturity			1.000	0.596**	0.837**	-0.698**	0.477*	-0.642**	0.586*	-0.876**	0.656**	0.889**	0.861**
No. of Pods/Plant				1.000	0.930**	0.101	0.588*	0.039	0.976**	-0.703**	0.678**	0.882**	0.877**
No. of Clusters/Plant					1.000	-0.225	0.574*	-0.262	0.918**	-0.830**	0.738**	0.975**	0.958**
No. of Pods/Cluster						1.000	-0.144	0.776**	0.077	0.532*	-0.201	-0.361	-0.345
No. of seeds / pod							1.000	-0.006	0.600**	-0.627**	0.776**	0.600**	0.647**
100 seed weight								1.000	0.069	0.433	-0.374	-0.330	-0.254
Yield / plant									1.000	-0.694**	0.670**	0.870**	0.879**
Pod wall thickness(mm)										1.000	-0.726**	-0.908**	-0.898**
Pod length(cm)											1.000	0.736**	0.725**
PD % at 40R°C												1.000	0.980**
PD % at 80R°C													1.000

*Significant at 5 % (0.468) and ** Significant at 1 % (0.590)

Table 3
Phenotypic correlation analysis between pod shattering percentage at 40°C and associated with other seed related traits in Cross-III (MACS-450 × Kalitur).

Traits	*Days to 1st flowering*	*Days to 50% flowering*	*Days to maturity*	*No. of pod/ plant*	*No. of cluster/ Plant*	*No. of pods/ cluster*	*No. of seeds/ pod*	*100 Seed wt.*	*Yield/ plant*	*Pod wall thickness (mm)*	*Pod length (cm)*	*PD% at 40°C*	*PD% at 80°C*
Days to 1st flowering	1.000	0.884**	-0.732**	-0.476*	-0.558*	0.417	-0.382	0.598**	-0.676**	0.719**	-0.246	-0.687**	-0.656**
Days to 50 % flowering		1.000	-0.808**	-0.702**	-0.791**	0.438	-0.523*	0.581*	-0.786**	0.707**	-0.294	-0.851**	-0.847**
Days to maturity			1.000	0.481*	0.577*	-0.474*	0.562*	-0.664**	0.481*	-0.870**	0.308	0.816**	0.780**
No. of Pods/Plant				1.000	0.978**	0.023	0.303	-0.127	0.780**	-0.452	0.571*	0.849**	0.887**
No. of Clusters/Plant					1.000	-0.124	0.416	-0.238	0.790**	-0.556*	0.530*	0.908**	0.934**
No. of Pods/Cluster						1.000	-0.471*	0.599**	-0.041	0.299	0.168	-0.288	-0.192
No. of seeds / pod							1.000	-0.209	0.464	-0.642**	0.407	0.468*	0.573*
100 seed weight								1.000	-0.049	0.437	0.111	-0.528*	-0.317
Yield / plant									1.000	-0.559*	0.498*	0.653**	0.788**
Pod wall thickness mm)										1.000	-0.507*	-0.761**	-0.784**
Pod length(cm)											1.000	0.517*	0.598**
PD % at 40R°C												1.000	0.954**
PD % at 80R°C													1.000

*Significant at 5 % (0.468) and ** Significant at 1 % (0.590)

The yield/plant positively and significantly correlated with pod shattering at 40°C (0.653) and pod shattering at 80°C (0.788) and pod length (0.498), While pod wall thickness (-0.559) was negatively significant with yield per plant. Pod wall thickness was negatively and significant correlation with while highly significant with pod shattering at 40°C (-0.761), pod shattering at 80°C (-0.784) and pod length (-0.507). Pod length was positive and significantly correlated to pod shattering at 40°C (0.517) and pod shattering at 80°C (0.598). The pod shattering percentage at 40°C was positively and highly significant with pod shattering at 80°C (0.954).

The degree of pod shattering was positive and significantly correlation observed with no. of cluster per plant and pod length for all the three crosses at 40°C and 80°C pod shattering in soybean. Positive correlation with days to maturity, no. of pods per plant, no. of seeds per pod and yield per plant for both the crosses II and III, while, it was negative for Cross I at 40°C and 80°C. whereas, high magnitude of significant and negatively correlation was observed with pod wall thickness, with the reduction of pod thickness shattering percentage increase (Table 3).

Among the observed morphological and phonological traits, both days to 1st flowering and days to 50% flowering showed positive effect in cross II whereas, cross I and cross III were negatively significant for pod shattering at 40°C and 80°C. Cross I had negative association with no. of pods per plant and no. of seeds per pod while, cross II and cross III were positive and significantly correlated at 40°C and 80°C pod shattering. The days to maturity and yield per plant were negative and significantly correlated in cross I while, in cross II and cross III they showed positively significant correlation with 40°C and 80°C pod shattering (Table 4).

Among the observed pod characteristics negatively correlation of shattering percentage both at 40°C and 80°C pod shattering with No. of pods per cluster and 100 seed weight for all the three crosses, whereas, high magnitude of significant and negatively correlation was observed with pod wall thickness, with the reduction of pod thickness shattering percentage increase. It is in agreement with Thompson and Huges (1996) and Morgan, *et al.* (2000). Tiwari and Bhatia (1995) had observed that pod wall thickness and length of bundle cap on the dorsal side of the pod and Pod wall thickness were significantly negatively correlated with the degree of pod shattering. Positive and significantly correlation was observed with no. of cluster per plant and pod length for all the three crosses at 40°C and 80°C pod shattering in soybean. As per association and correlation coefficient analyses that

Table 4
Correlation of pod morphological characters with pod shattering in soybean.

Sr.No.	*Characters*	*Pod shattering at 40°C*			*Pod shattering at 80°C*		
		Cross I	*Cross II*	*Cross III*	*Cross I*	*Cross II*	*Cross III*
1	Days to 1st flowering	-0.729**	0.203	-0.687**	-0.684**	0.155	-0.656**
2	Days to 50 % flowering	-0.936**	0.184	-0.851**	-0.947**	0.159	-0.847**
3	Days to maturity	-0.816**	0.889**	0.816**	-0.861**	0.861**	0.780**
4	No. of Pods/Plant	-0.423	0.882**	0.849**	-0.426	0.877**	0.887**
5	No. of Clusters/Plant	0.613**	0.975**	0.908**	0.635**	0.958**	0.934**
6	No. of Pods/Cluster	-0.214	-0.361	-0.288	-0.173	-0.345	-0.192
7	No. of seeds / pod	-0.075	0.600**	0.468*	-0.061	0.647**	0.573*
8	100 seed weight	-0.416	-0.330	-0.528*	-0.368	-0.254	-0.317
9	Yield / plant	-0.482*	0.870**	0.653**	-0.504*	0.879**	0.788**
10	Pod wall thickness (mm)	-0.932**	-0.908**	-0.761**	-0.910**	-0.898**	-0.784**
11	Pod length(cm)	0.487*	0.736**	0.517*	0.450	0.725**	0.598**

positive and significantly correlation with for all the three crosses at 40°C and 80°C pod shattering in soybean, number of cluster per plant and pod length. The genotype having the small pod having less seeds were tolerant to pod shattering, whereas, pod wall thickness and no. of pods per cluster and 100 seed weight were found to be significantly negative correlated with the degree of pod shattering. Pod wall thickness was found to be important in resistance to pod shattering in this study and could be potentially serve as criteria for the selection of resistance to this phenomenon. As per the association and correlation with pod shattering percentage was found that to be significantly negative correlated with pod wall thickness. Thicker the pod wall lesser the pod shattering. Therefore variety with bigger pod diameter is a reliable index for use in selecting for shattering resistance and a good indicator for pod shattering in breeding programmes.

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References

A.V.R.D.C., (1979), International Cooperators Guide: Suggested cultural practices for soybean. No. Asian Vegetable Research. Development Center, Taiwan. pp. 79-112.

Bailey, M.A., Mian, M.A.R., Carter, T.E., Ashley, D.A. and Boerma, H.R. (1997), Pod dehiscence in soybean: Identification of quantitative trait loci. *J. Hered.,* **88**: 152–154.

Bhor, T.J., V.P.Chimote and M.P.Deshmukh. (2014), Inheritance of pod shattering in soybean (*Glycine max* (L.) Merrill). *Electronic J. Plant Breeding*, **5**(4): 671-667.

Carpenter J.A. and Fehr, W.R. (1986), Genetic variability for desirable agronomic traits in population containing Glycine soja germplasm. *Crop Sci*., **26**: 681-686.

Caviness, C.E. (1963), A physiological and genetic study of shattering in soybean. Ph. D. Dissertation, University of Missouri.

International Institute of Tropical Agriculture (IITA), (1986), A laboratory method for evaluating resistance to pod shattering in soybeans. Annual Report. 58-59. IITA, Ibadan, Nigeria.

Mohammed, H. (2010), Genetic analysis of resistance to pod shattering in soybean (*Glycine max*. (L) Merrill). Ph.D. thesis Department of crop and soil science, Kwame Nkrumah University of Science and Technology, Kumasi.

Morgan, C.L., Bruce, D.M., Child, R., Ladbrooke, Z.L. and Arthur, A.E. (1998), Genetic variation for pod shatters resistance among lines of oilseed rape developed from synthetic *Brassica napus. Field Crops Res*., **58**: 153 -165.

Morgan, C.L., Ladbrooke, Z.L., Bruce, D.M., Child, R. and Arthur, A.E. (2000), Breeding oilseed rape for pod shattering resistance. *J. Agr. Sci*., **135**: 347-359.

*Galton, F. (1888), Correlation and their measurement, chiefly from anthropometric data. *Proc. R. Soc.* London. **45**: 219: 247.

Thompson K.F. and Huges W.G. (1986), Breeding varieties. In: Scarisbrick D.H.R.W. Daniels, (eds). Oilseed Rape. Colins Professional and Technical Bulletin, pp. 32-82.

Tiwari, S.P. and Bhatnagar, P.S. (1997), Screening methods for pod shattering in soybean. *In* Proceedings. World Soybean Research Conference V, Chiang Mai, Thailand. Kasetsart University Press, pp. 23-24.

Tiwari, S. and Bhatia V.S. (1995), Characterization of pod anatomy associated with resistance to pod-shattering in soybean. *Ann Bot.,* **72**: 483–485.

Tukamuhabwa, P. (2000), Genetics of resistance to pod shattering in soybean. Ph.D. thesis. Department of Crop Science. Makerere University Kampala.