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Selecting soybean (*Glycine max*) genotypes for insertion height of the lowest pod, the useful trait for combine harvester

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ABSTRACT

Field experiments were conducted during 2008 and 2009 using 90 genotypes to screen for height of insertion of the lowest pod, the trait useful for combine harvester. Data was recorded on plant height (cm), height of insertion of the lowest pod (cm) when erect, lodging of the plant in degrees (ø), stem diameter (cm), number of nodes, number of branches and yield. Results of analysis of variance showed significant differences among genotypes in terms of traits under study, which indicate the existence of genetic variation. Correlation coefficient indicated that the grain yield was not significantly associated with all studied traits, which showed non-significant association. Plant height and nodes were negatively correlated with lodging of plants in degrees. First pod height was significant and positively associated with height as well as number of nodes/plant. Stem diameter was positively associated with the nodes/plant. Highest yield was observed in genotypes JS 95-60, Co Soya 2, JS 71-05, MACS 450, VL Soya 21, MAUS 47, KB -79, MAUS 81, PS 1225, NRC 37 and MAUS 71 and was found at par with JS 95-60. However, the genotypes JS 71-05, MAUS 47, PS 1225, NRC 37 and MAUS 71 had a yield at par with JS 95-60, with the lodging angle in degrees (> 65.00°), having pod height above 12 cm, these genotypes are recommended for mechanical harvesting.

Key words: *Glycine max,* Lodging, Lowest pod height, Soybean, Yield

The soybean [*Glycine max* (L.) Merrill, (2n = 40)] is an economically important leguminous crop, known for its highly valued protein and oil because of its use in food, feed, and industrial applications. It enriches the soil by fixing nitrogen in symbiosis with bacteria. In the international trade, soybean is ranked number one in the world among the major oil crops such as rapeseed, groundnut (peanut), cottonseed, sunflower seed, linseed, sesame seed, and safflower (Chung and Singh 2008).

Many studies have indicated that improvement in weed control, planting and harvest machinery as well as incorporation of disease and lodging resistance into elite soybean genotypes have contributed towards the yield improvement (Morrison *et al.* 2000, Ustun *et al*. 2001, Singh 2007, Jin *et al*. 2010). Technological development in agriculture is very essential in increasing the productivity of the land. Among others, mechanization of agriculture through the use of improved machinery forms an integral part technological advancement. Harvesting operation is one of the most labour-intensive operations. Therefore, the use of combine harvesters present a possible solution for these problems (Elsaied *et al*. 2009). The height of bottom pods on soybean plants can be a major factor affecting seed loss at harvest, as seeds are lost if pods are lower than the cutting height of the combine cutterbar.

The selection of soybean genotypes with insertion point of lowest pod before and after lodging depends on the magnitude of the genetic variability and the extent of heritability of desirable characters. Thus, present work aims at studying the soybean genotypes for its genetic variability and evaluation of the performance of different genotypes. This information would lead to desirable plant type for future breeding programme for combine harvester thresher as severe labour scarcity is observed at the time of harvesting of the crop.

MATERIALS AND METHODS

Ninety soybean varieties were grown in a randomized block design with three replications during rainy (*kharif*) season of 2008 and 2009 at the Directorate of Soybean Research, Indore Madhya Pardesh which is situated at 22º 4'37''N latitude, 75º 52'7''E longitude and altitude of 540 m above the mean sea level. The varieties were sown in six rows in 5 m length (spacing 45 cm × 10 cm). The experiments were carried out on deep black cotton soils with *p*H 7.6 to

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8.1, low to medium in organic carbon and available phosphorus and high in potassium (Typic Chromusterts and Lithic Vertic Ustochrepts). Before sowing 20 kg/ha Nitrogen, 60 kg/ha Phosphorus and 20 kg/ha Potassium were applied in the form of commercial fertilizers.

Data was recorded on height of insertion of the lowest pod (cm) before lodging of plant, lodging of plant in degrees (θ), plant height (cm), stem diameter (cm), number of nodes and number of branches and seed yield. Seed yield was recorded on net plot basis (kg/13.5 m^2). Plant height and stem diameter was measured at maturity. Height of the lowest pod (Hlp) from the soil surface after lodging was computed using trigonometry.

$$Hlp = \sin \theta \times \text{pod height of erect plant}$$

Where, ø is the angle measured in degrees between soil surface and lodged stem of soybean plant by protractor. Analysis of variance, phenotypic variances, genotypic variances and correlations were carried out as described by Singh and Chaudhary (1985). The data from two cropping seasons were pooled for statistical analysis. Correlations among the traits were computed on the basis of mean values of two years.

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for all the characters studied (Table 1). The wide range of variabilities among soybean genotypes were also observed by Jyoti and Tyagi (2005), Malik *et al.* (2006) and Zafar *et al*. (2010). This result implied that the population of soybean genotypes would respond positively to selection. The phenotypic expression of plant height, nodes/ plant, branches/ plant and yield were reasonably influenced by the combined influence of both the varying seasons and the genotypic potential. The genotypic differences in yield of soybean and their further modification by the environment through its interaction have also been amply demonstrated by Ramteke and Husain (2008).

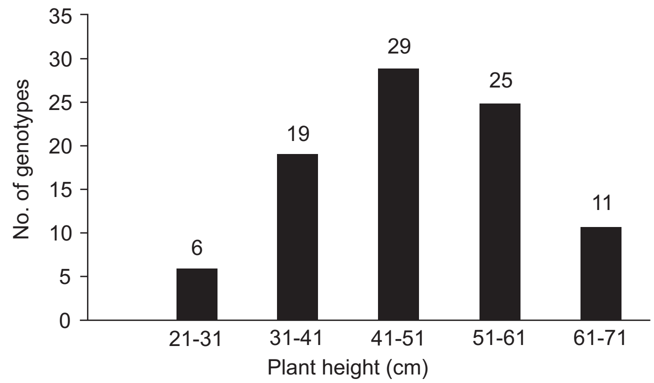

Fig 1 Distribution of plant height among 90 genotypes of the soybean

Plant height at maturation varied from 21.30 to 70.67 cm (Table 2). These results are conformity with the findings of Dhillon *et al.* (2005) who recorded plant height in the range of 54.6 – 88.0 cm. Out of total 90 genotypes, 27.78% genotypes were observed with short (≤41 cm) height, whereas 32.22%, 27.78% and 12.22% genotypes with 41–51, 51–61 and 61–71 cm height respectively (Fig 1). The genotypes ADT 1, Gujarat Soya 2, Improved Pelican, MAUS 61-2, KHSb 2, Type 49, CO 1, Kalitur, JS 80-21, MACS 124 and 'Lee' were the tallest ones. In contrast, PRS 1, VL Soya 2, LSb 1, JS 2, NRC 7 and PS 564 were the shortest ones at maturation. Correlation coefficient study (Table 3) showed that the height was significant and positively associated with the number of nodes per plant and pod height but negatively correlated with lodging of the plant in degrees.

Number of nodes.plant ranged from 8.33 to 17.50 with

Table 1 Analysis of variance

Source of variation	Degree of freedom	Plant height (cm)	Nodes/ plant	Branches/ plant	Stem diameter (cm)	Lodging in degree	Pod height before lodging plant	Pod height after lodging	Yield (kg)/plot
Genotype	89	656.19**	25.38**	7.88**	0.07**	974.87**	87.42**	85.51**	1.50**
Environment	1	512.36**	54.78**	87.20**	0.58**	112.07ns	15.34ns	12.79ns	471.77**
Replication in season	4	64.26ns	3.40ns	2.57ns	0.03ns	17.91ns	17.31ns	13.38ns	0.42*
Variety × environment	89	364.34**	14.56**	6.88**	0.004ns	8.92ns	2.71ns	2.38ns	0.67**
Pooled error	356	26.42	2.20	1.99	0.02	35.64	11.04	9.85	0.15

*and **significant with respect to pooled error at 5% and 1% respectively

Table 2 Range, grand mean and CV of eight characters studied (n = 90)

Genotype	Plant height (cm)	Nodes/ plant	Branches/ plant	Stem diameter	Lodging in degree	Pod height before lodging	Pod height after lodging	Yield (kg 13.5m^{-2})
Range	21.3–70.67	8.33–17.50	2.50–8.83	0.37–0.92	25.33–87.50	7.00–24.17	6.47–23.74	0.64–3.03
Grand mean	48.24	12.62	4.57	0.66	69.44	16.80	15.18	1.59
C V	10.65	11.75	30.82	21.99	8.60	19.78	20.68	24.57

Table 3 Correlation coefficient of agronomic characteristics of soybean genotypes (n = 90)

	Plant height (cm)	Nodes/ plant	Branches/ plant	Stem diameter	Lodging in degree	Pod lodging height before	Pod height after lodging
Nodes/plant	0.702**						
Branches/plant	0.129	0.130					
Stem diameter	0.188	0.223*	0.158				
Lodging in degree	–0.356**	–0.208*	–0.030	0.083			
Pod height before lodging	0.472**	0.447**	0.169	0.214*	–0.224*		
Pod height after lodging	0.288**	0.351**	0.143	0.276**	0.292**	0.845**	
Yield (kg)/plot	-0.167	-0.111	–0.124	–0.039	0.082	–0.117	–0.083

grand mean 12.62. These were positively correlated with stem diameter and pod height, while negatively with lodging of the plant in degrees. In our study no significant correlation was observed between nodes/plant and yield; however, Bizeti *et al*. (2004) showed high correlation and had direct effect on soybean grain yield.

Branches/plant were ranging from 2.50 to 8.83 (Fig 2) and no significant correlation was established with all character studied (Table 3). Rasaily *et al.* (1986) and Malik *et al*. (2006) reported similar results and obtained considerable genotypic variability for numbers of branches.

Stem diameters ranged from 0.37 cm to 0.92 cm, found significant and positively associated with the first pod height and nodes/plant. Thick stem diameters (0.80–1.0 cm) were observed in genotypes PK 472, Gujarat Soya 1, Type 49, PS 564, RKS 18, RAUS 5, MACS 124, PS 1092, NRC 37 and MAUS 61 while thin stems (0.37-0.50 cm diameter) in PRS 1, VL Soya 2, MAUS 61-2, VL Soya 1, JS 90-41, VL Soya 21 and KB 79.

The significant differences were observed between genotypes for lodging in degrees. It ranged from 25.33° to 87.50° (Table 2, Fig 3). It was negatively correlated with plant height, nodes/plant and first pod height measured before plant lodging but positively correlated with the pod height after lodging of the plant (Table 3). Lodging is considered to be a serious trouble. Genetic improvement of soybean in the U S (Ustun *et al*. 2001, Wilcox 2001) has led to earlier, shorter plants which are more tolerant to lodging compared

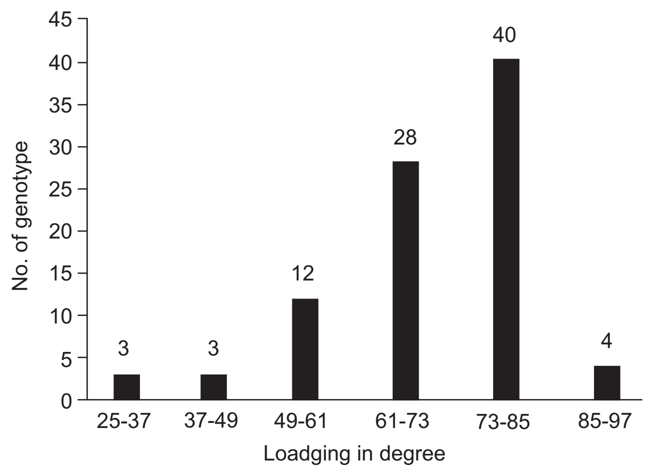

Fig 3 Distribution of lodging in degree among 90 genotypes of the soybean

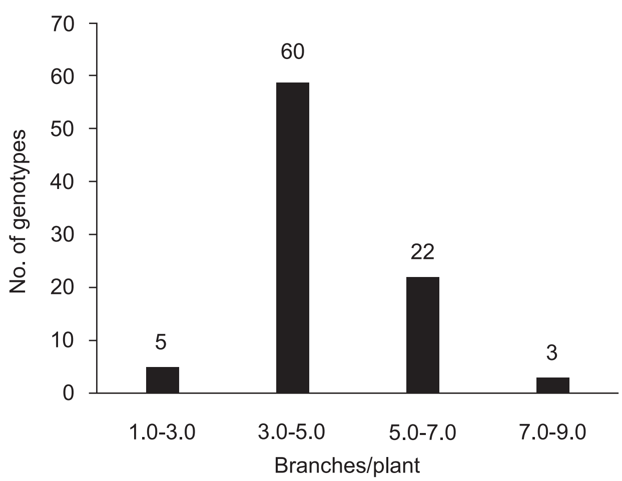

Fig 2 Distribution of branches/plant among 90 genotypes of the soybean

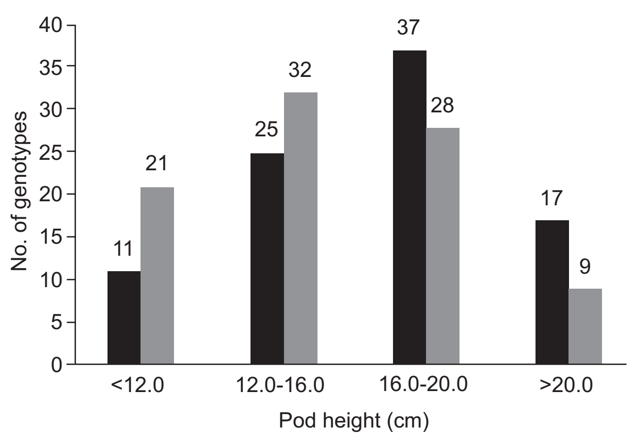

Fig 4 Distribution of pod height before and after lodging among 90 genotypes of the soybean

to taller plants; the same trend was also observed in Northeast China (Jin *et al*. 2010). Development of shorter genotypes of soybean reduced the problem to some extent, but not completely. Lodging is induced by external forces like wind, rain or hail. Continuous rainfall for a week is more related to lodging. Wind speed played secondary role in lodging. Higher than the normal wind speed resulted in lodging. In most cases, lodging tends to be more when crop is near harvest. Surplus moisture in the upper soil layer weakens the anchorage of the root system. Poor soil aeration may increase susceptibility to lodging due to the effects on respiration inhibition and changes in metabolism which promote cell elongation and thus increase lodging. The promotion of lodging due to poor aeration and high moisture content of the soil is especially evident in water logged fields. Soil aeration and soil structure also affect nitrogen availability, which in turn affects lodging. Taller plants may provide a higher rate of lodging given the fact that they have thinner stems, becoming more subject to wind action.

The heights of bottom pods are considered when crop is harvested by combine harvester. Seeds are lost if pods are lower than the cutting height of the combine cutterbar. For the character height of insertion of the first pod, the 11 genotypes (LSb 1, JS 95-60, PRS 1, PS 1 024, VL Soya 2, KB 79, PUSA 16, PS 1 029, NRC 12, MAUS 61-2 and VL Soya 1) plus after lodging took 10 more genotypes (C o 1, MACS 450, Durga, JS 335, VL Soya 21, MAUS 81, RKS 18, Punjab 1, SL 525, and TAMS 98-21) thus total 21 genotypes were below the 12 cm standard (Fig 4). High operational yield of the harvesters, associated with minimum harvest losses, demands that minimum height of soybean pod insertion should be at least 12 cm. While studying Cober *et al*. (2000) observed that bottom pods on tall determinate lines were set almost twice as high as bottom pods on indeterminate cultivars and suggested that tall determinate lines may be valuable in environments where harvesting losses result from low bottom pods.

Yield was measured in kg/plot (13.5m^2) and was ranging from 0.64 to 3.03 with grand mean 1.59 kg/plot. The results are supported with the findings of Rasaily *et al.* (1986) who performed experiments and obtained considerable genotypic variability for seed yield. Ghatge and Kadu (1993) found the similar results and observed high variability for seed yield. In our study yield was not established significant correlation with all the traits studied. However, highest yield was observed in genotypes JS 95-60, Co Soya 2, JS 71-05, MACS 450, VL Soya 21, MAUS 47, KB 79, MAUS 81, PS 1 225, NRC 37 and MAUS 71 and found at par with JS 95-60. The genotypes MACS 450 and Co soya 2 were found with most lodging property with 26.67° and 47.00° respectively. The genotype JS 95-60, KB 79 had the lowest pod at 9.17 and 10.83 cm respectively. After lodging, the insertion height of the lowest pod in the genotypes, (viz MACS 450, KB 79, JS 95-60, JS 335, VL Soya 21, MAUS 81 and RKS 18) was reduced and found below 12 cm. The genotype JS 95-60 had the highest yield, even with the first pod insertion height lower than 12 cm and it was at par with the genotypes Co Soya 2, JS 71-05, MACS 450, VL Soya 21, MAUS 47, KB 79, MAUS 81, PS 1 225, NRC 37 and MAUS 71 for this characteristic; it also had a lodging angle 86.67° which is acceptable but need to improve for insertion height of the lowest pod. However, the genotypes JS 71-05, MAUS 47, PS 1 225, NRC 37 and MAUS 71 had a yield at par with JS 95-60, with the lodging angle in degrees (> 65.00°), having pod height above 12 cm, therefore, it is suggested that these genotypes are recommended for mechanical harvesting and further these genotypes could be utilized to develop physiologically efficient cultivars with high yield potential. Results obtained from this study can make better choice for soybean breeders for selecting genotypes among large number of accessions by calculating actual pod height using trigonometric formula of lodged plant.

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