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Seed Longevity and Its Association with Agronomic Traits in Soybean [*Glycine max* (L.) Merrill]

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ABSTRACT

Background: Soybean is an important oilseed crop but it has poor seed longevity. Studies on seed longevity are very complex and hence, an indirect selection criterion should be identified. In this study, seed longevity and its association with agronomic traits of seven soybean varieties was evaluated in the year 2019-2020.

Methods: Seed were kept for storage under ambient conditions for a period of 16 months (January 2019 to May 2020). Their germination was recorded at bimonthly intervals and seed longevity was inferred as the time period in months up to which the seed maintains its germination percentage above IMSCS.

Result: Accordingly, Palam Early Soya 1 and Him Palam Hara Soya were classified as having short seed longevity (12 months). Hara Soya, Shivalik, Him Soya and Palam Soya were classified as having medium seed longevity (14 months). Whereas, PS 1556 was classified as having long seed longevity (>16 months). Further, it was found that seed longevity was positively associated with number of pods per plant and seed yield, and negatively associated with number of branches per plant and 100-seed weight. This study presents an indirect selection criterion based on some easily accessible parameters which have strong association with seed longevity.

Key words: Association, Correlation, Soybean, Variability.

INTRODUCTION

Soybean (*Glycine max* L. Merrill) also called as the 'Golden Bean' or 'Miracle crop' of the 21st century, alone contributes about 58 per cent of the global oilseed production. Today it ranks first in oilseed production and is grown on an estimated six per cent of the world's arable land. Since 1970s, the area under soybean production has the highest per cent increase among all the major crops (Hartman *et al.,* 2011). India ranks 5th in soybean production in the world (Pallavi *et al.,* 2018). The major soybean growing states in India are Maharashtra, Madhya Pradesh, Karnataka, Rajasthan and Telangana (Anonymous, 2019).

Seed is an important plant product from which an entire plant will develop and hence, it is important to keep the seed alive till its sowing in the ensuing season. Deterioration of seed in storage is one of the basic reasons for low productivity and non-availability of high vigour seeds at the time of sowing in soybean (Patel *et al.,* 2017). Some seeds are naturally short lived and decline faster than other seeds in storage and soybean is one of them (Usberti *et al.* 2006; Gokhale, 2009).

Storability of seed is mainly a genetic character (Mahesha *et al.* 2001) and in soybean it is governed by 1-2 genes (Verma and Ram, 1987). Seed longevity is influenced by cytoplasmic gene action as well as maternal plant genome (Kueneman, 1983). Soybean is a very important oilseed crop but it is classified under least storable group (Tiwari and Bhatia, 1995) due to its high moisture content, high oil content (Balesevic-Tubic *et al.,* 2010), high protein content, physiological decay and thin seed coat character (Delouche and Baskin, 1973). The soybean seed is highly susceptible to field weathering and mechanical damage which adversely affect its longevity (Pawar *et al.,* 2019). Additionally, its genotypes differ in their ability to maintain seed longevity (Wine and Kueneman, 1981; Khare *et al.* 1996). Seed deterioration during storage is also associated with various metabolic and chemical alterations that vary among genotypes in soybean (Vijayakumar *et al.,* 2019). Seed longevity is a complex trait hence it often remains a barrier in breeding programs.

Seed longevity is a central pivot of the preservation of biodiversity, being of main importance to face the challenges linked to global climate change and population growth. This complex, quantitative seed quality trait is acquired on the mother plant during the reproductive phase of seed development. Understanding what factors contribute to lifespan is one of the oldest and most challenging questions in plant biology (Zinsmeister *et al.,* 2020). Studies of seed

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longevity under conventional or optimal storage conditions would take a lot of time to complete and studies conducted under accelerated ageing or controlled conditions require a lot of skills for the maintenance of appropriate conditions for getting accurate results. Hence, it would be advisable if an indirect selection criterion based on some easily accessible agro-morphological and seed quality parameters that have strong association with longevity can be identified.

MATERIALS AND METHODS

The experiment was conducted during 2019-2020 at the Department of Seed Science and Technology, CSK HP Krishi Visvavidyalaya, Palampur India. The experimental material involved freshly harvested and well graded seeds of seven soybean varieties grown in the hills of North Western Himalayan region of India, namely Hara Soya, Shivalik, Palam Soya, Him Soya, PS 1556, Palam Early Soya 1 and Him Palam Hara Soya 1.

In order to investigate the seed longevity, varieties were packed in HDPE bags and kept for storage (January 2019 to May 2020) in four replicates under ambient conditions using completely randomized design (CRD) in the Seed Technology Laboratory. The germination was recorded at bimonthly intervals until it fell below Indian Minimum Seed Certification Standards (70%) using between paper methods as per ISTA procedure (Anonymous, 2019) in four replications of 100 seeds each.

Germination percentage =

$$\frac{\text{Number of seeds germinated into normal seedlings}}{\text{Total number of seeds kept for germination}} \times 100$$

Seed longevity was inferred as the time period up to which the seed maintains its germination percentage above the IMSCS.

In order to investigate the association of seed longevity with agronomic traits, the field experiment was laid out in 3 replications. Each genotype was grown in 4 rows of 3 m length at a spacing of 45 X 15 cm. Recommended package of practices were followed to raise a healthy crop. Observations were recorded in ten randomly selected plants from each plot for the traits *viz*., days to 50 per cent flowering, branches per plant, plant height (cm), pod length (cm), pods per plant, seeds per pod, 100-seed weight (g), days to 75 per cent maturity, biological yield per plot (kg), seed yield per plot (kg), harvest index (%) and seed yield (q/ha). Standard statistical procedures were used for analysis of variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance. The association analysis was worked out using MVM software.

RESULTS AND DISCUSSION

The germination percentage recorded at bimonthly intervals, declined gradually with the advancement of storage period (Fig 1). Soybean seeds have a fragile seed coat which is prone to cracking hence, results in poor germination (Dao and Ram, 1997). The decline may also be attributed to depletion of food reserves and decline in metabolic processes as a result of ageing.

Seed longevity was inferred as the time period in months up to which the seed maintains its germination percentage above the Indian Minimum Seed Certification Standard (IMSCS). In case of soybean the IMSCS is 70 per cent. The seed longevity of seven soybean genotypes under study is represented in (Fig 2). Tentatively, Palam Early Soya 1 and Him Palam Hara Soya 1 maintained the germination percentage above the IMSCS (70%) only up to 12 months of storage. The seed longevity duration clearly indicated that these varieties could be stored safely only until next growing season and cannot be carried forward. On the other hand, Hara Soya, Shivalik, Him Soya and Palam Soya varieties maintained the germination percentage above the IMSCS up to 14 months of storage. However, the highest storage life was recorded for PS 1556 as its germination percentage did not fall below the IMSCS even after 16 months of storage. The better duration of seed longevity indicated that these five varieties could be stored subsequently up to two growing seasons without any compromise in germination. Accordingly, seed longevity was found to be comparatively

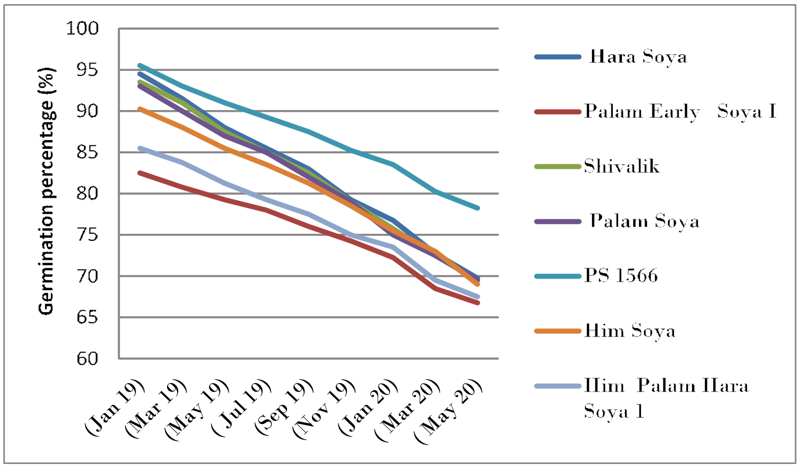

Fig 1: Germination percentage of seven soybean varieties during 16 months of storage.

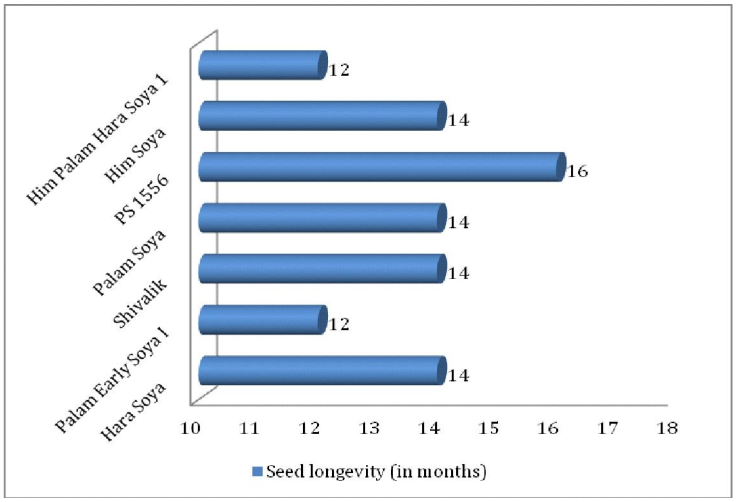

Fig 2: Seed longevity of seven soybean varieties grown in North Western Himalayan Region.

Table 1: Mean performance of seven genotypes of soybean for 12 agro-morphological traits.

Variety	Days to 50 % flowering	Branches/ plant	Plant height (cm)	Pod length (cm)	Pods/ plant	Seeds/ pod	100-seed weight (g)	Days to 75 % maturity	Biological yield/plot (kg)	Seed yield/ plot (kg)	Harvest index (%)	Seed yield (q/ha)
Hara soya	64.0	10.3	71.7	4.3	63.9	2.7	11.47	98.0	6.1	1.64	26.7	30.37
Palam early Soya 1	64.3	10.2	82.3	3.5	56.1	2.4	14.06	94.0	7.2	1.30	18.2	24.07
Shivalik	67.7	10.4	95.4	3.5	71.7	2.3	12.93	108.0	4.9	1.79	36.3	33.20
Palam soya	64.0	11.4	80.6	3.8	62.0	2.4	13.79	95.0	6.9	1.75	25.3	32.34
PS 1556	66.3	9.2	86.3	3.7	72.6	2.6	09.73	102.0	7.3	1.90	26.1	35.18
Him soya	64.0	9.3	74.3	3.4	65.3	2.3	11.44	96.0	7.1	1.54	21.7	28.51
Him palam Hara soya 1	69.0	12.3	95.8	4.4	63.0	2.6	20.46	108.0	5.9	1.73	29.2	32.05
Mean	65.6	10.4	83.8	3.8	64.9	2.5	13.41	100.1	6.5	1.66	26.0	30.82
SE(m)±	0.424	0.078	0.466	0.065	0.54	0.052	0.651	0.218	0.283	0.075	0.837	1.386
CD (5%)	1.321	0.242	1.451	0.203	1.682	0.163	0.209	0.68	0.882	0.233	2.609	4.318

Table 2: Estimates of mean sum of squares, range and other genetic parameters for 12 agro-morphological traits in soybean.

Trait	Mean sum of squares due to genotypes	Range	Phenotypic Coefficient of Variation (PCV %)	Genotypic Coefficient of Variation (GCV %)	Heritability in broad sense (%)	Genetic advance as % of mean
Day to 50% flowering	12.83**	64 - 69	3.18	3.14	97.80	6.40
Branches/plant	3.64**	9.2 - 12.3	10.59	10.55	99.13	21.63
Plant height (cm)	266.43**	71.7 - 95.8	11.30	11.27	99.46	23.15
Pod length (cm)	0.49**	3.4 - 4.4	10.56	10.18	92.90	20.21
Pods/plant	98.09**	62.0 - 72.6	8.87	8.87	98.09	17.92
Seeds/ pod	0.08**	2.3 - 2.7	6.87	6.25	82.84	11.72
100-seed weight (g)	35.87**	9.7 - 20.5	20.09	20.05	99.59	41.21
Days to 75% maturity	106.43**	94.0 - 108.0	5.99	5.93	98.15	12.11
Biological yield/plot (kg)	2.24**	5.9 - 7.3	14.34	12.96	81.63	24.12
Seed yield/ plot (kg)	0.12**	1.30 - 1.90	13.07	11.37	75.69	20.37
Harvest index (%)	137.88**	17.3 - 39.0	26.55	26.16	97.07	53.10
Seed yield (q/ha)	39.81**	24.07 - 35.18	13.07	11.38	75.80	20.40

*Significant at 1% level of significance.

Table 3: Estimates of phenotypic (P) and genotypic (G) correlation coefficients between agronomic traits and seed longevity in seven varieties of soybean.

Trait		Days to 50% flowering/	Branches plant	Plant height	Pod length	Pods/ plant	Seeds/ pod	100-seed weight	Days to 75 % maturity	Biological yield/plot	Seed yield /plot	Harvest index	Seed yield/ha
Branches/plant	P	0.4651**											
	G	0.4675											
Plant height	P	0.9093**	0.4715**										
	G	0.9287	0.4795										
Pod length	P	0.2727	0.6352**	0.0344									
	G	0.2881	0.6630	0.0347									
Pods/plant	P	0.4158*	-0.3477	0.3206	-0.1431								
	G	0.4245	-0.3545	0.3271	-0.1440								
Seeds/pod	P	0.0358	0.1224	-0.1884	0.6929**	0.0190							
	G	0.0347	0.1371	-0.2084	0.7859	0.0059							
100-seed weight	P	0.6034**	0.9012**	0.4784**	0.7385**	-0.2691	0.2223						
	G	0.6075	0.9072	0.4812	0.7594	-0.2719	0.2262						
Days to 75%	P	0.9373**	0.3564	0.8235**	0.2891	0.5929**	0.0622	0.5148**					
maturity	G	09578	0.3628	0.8347	0.3027	0.6005	0.0587	0.5197					
Biological	P	-0.5651**	-0.3877*	-0.4886**	-0.2632	-0.3238	0.0533	-0.4551*	-0.7007**				
	G	-0.6158	-0.4195	-0.5577	-0.2711	-0.3392	0.1584	-0.4882	-0.7681				
Seed yield/plot	P	0.4509*	0.1287	0.3783*	0.2084	0.7297**	0.1676	0.0843	0.5393**	-0.1444			
yield/plot	G	0.5237	0.1467	0.4284	0.2867	0.8514	0.2780	0.1111	0.6490	-0.3905			
Harvest index	P	0.6530**	0.2752	0.6250**	0.1409	0.6491**	-0.1253	0.2923	0.8131**	-0.8271**	0.6123**		
	G	0.6748	0.2797	0.6325	0.1429	0.6660	-0.1476	0.2960	0.8401	-0.9322	0.6723		
Seed yield/ha	P	0.4534*	0.1297	0.3802*	0.2095	0.7303**	0.1680	0.0862	0.5420**	-0.1465	1.000**	0.6139**	
	G	0.5261	0.1477	0.4303	0.2877	0.8517	0.2781	0.1131	0.6513	-0.3926	1.000	0.6738	
Seed longevity	P	-0.1433	-0.5328**	0.1879	-0.2582	0.6959**	0.1529	-0.5803**	0.1280	0.1737	0.5017**	0.1314	0.5003**
	G	-0.1704	-0.6229	--0.2147	-0.2217	0.8145	0.1744	-0.6753	0.0030	0.1996	0.7260	0.1941	0.7243

*****Significant at 5% level of significance, **Significant at 1% level of significance.

higher in the present study, as compared to the study conducted by Viswanath *et al.* (2019) under Karnataka conditions who reported maintenance of seed storability only up to nine months. Besides, Shelar and Shaikh (2002) also reported that germination percentage fell below IMSCS approximately after 11 months of storage under Maharashtra conditions. One of the possible reasons behind this difference could be comparatively hotter and humid conditions prevailing in Karnataka and Maharashtra all around the year as compared to the conditions at Himachal Pradesh.

The mean performance of seven genotypes of soybean for 12 agro-morphological traits are given in (Table 1). The mean sum of squares due to genotypes were significant for all the 12 agro-morphological traits at 1 per cent level of significance indicating the existence of considerable amount of genetic variability for all the traits studied. Many earlier reports had documented existence of sufficient variability among genotypes of soybean for agro-morphological traits (Ali *et al.* 2016; Ramyashree *et al.* 2016).

The estimates of mean sum of squares due to genotypes, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (in broad sense) and genetic advance as per cent of mean are given in (Table 2). The PCV was higher in magnitude than the GCV with respect to all the characters indicating existence of high genetic variability and influence of environment on the performance and expression of these characters. However, the differences between GCV and PCV values were very low for all the characters studied, indicating that the environmental effects in the manifestation of these parameters are minor. The present study revealed that heritability in broad sense was high (>70 %) for all the components under study, signifying lesser influence of environment and greater role of genetic component of variation. Therefore, selection for these traits on the basis of phenotypic expression can be effective and relied upon.

Seed longevity is a complex yet important seed trait. The screening of varieties for high seed longevity is tedious because of longer duration of experimentation periods and accuracy of controlled factors like RH and temperature to be maintained like in case of accelerated ageing tests. Therefore, an indirect selection criterion based on some easily scorable agro-morphological and seed quality parameters that have strong association with longevity, if identified can be very helpful. Estimates of phenotypic and genotypic correlations between agronomic traits and seed longevity are presented in (Table 3). In the present study, the correlation analysis revealed that, magnitude of correlation coefficients at genotypic level was higher than at phenotypic level indicating a strong linkage at genetic level. It reflects high degree of genetic association among traits under consideration which will not be broken up with changing environment. Chand (1999) performed experiments on different varieties of soybean and revealed similar results.

Seed longevity was found to be significantly and positively correlated with number of pods per plant and seed yield (Chavan, 2019). However, a significant negative association of seed longevity with 100-seed weight and number of branches per plant were also established (Naik *et al.* 2016; Tripathi and Khare, 2016; Chirchir *et al.* 2017). Among the two traits exhibiting positive association, the magnitude of association was stronger with number of pods per plant as compared to seed yield indicating thereby importance of number of pods per plant as important criteria for direct and positive selection for seed longevity. Similarly, amongst traits exhibiting negative association with seed longevity, the magnitude was higher in case of 100-seed weight indicating its importance as potential trait for negative selection towards improving seed longevity.

Additionally, moderate GCV and PCV values (10 to 25%) were observed for traits like 100-seed weight, number of branches per plant, seed yield per plot and seed yield per ha. High heritability (>70%) coupled with high genetic advance (>30%) was observed for 100-seed weight, whereas traits like number of branches per plant, seed yield per plot and seed yield per ha exhibited high heritability coupled (>70%) with moderate genetic advance (20-30%). High heritability coupled with high genetic advance as per cent of the mean for 100-seed weight showed that this trait was under the control of additive genes and selection for this character could be effective. Thus the genotypes exhibiting less number of branches and more number of pods with small sized seeds would be more productive and are likely to have higher germination percentage and/seed longevity under storage.

CONCLUSION

An ideal soybean genotype to have longer seed longevity accompanied with higher yield potential should have less number of branches per plant, more number of pods per plant and small sized seeds. The information generated under the present study on the magnitudes and direction of association between seed longevity and the component traits can be used in crop improvement programme to achieve the improvement in the desired direction with respect to seed longevity.

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