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Genetic variability and association studies for seed yield and longevity with component traits in soybean [*Glycine max* (l.) Merill.]

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ABSTRACT

The nature and extent of genetic variability and correlation coefficient for productivity traits like seed yield and longevity of 225 soybean genotypes were evaluated. Significant variability (5%) was recorded among genotypes for agronomic and seed quality parameters. Number of pods per plant (23.76%), test weight (21.61%), seed yield per plant (28.07%), final germination (36.7%), seed coat permeability (30.09%), electrical conductivity (40.09%) and germination reduction (40.03%) showed high phenotypic and genotypic coefficient of variation, heritability and genetic advance. The association studies revealed that, number of branches and pods per plant and test weight (g) showed positive and significant correlation with seed yield (g). Phenotypic and genotypic correlation for seed longevity was negatively correlated and significant with test weight (g), seed coat permeability (%) and electrical conductivity (dSm^{-1}). Superior genotypes like PK 7379, PI 284815, PI 204336, CO-1 and JS 79-307 were identified with high seed yield (3041.67-3708.33 kg/ ha) and good longevity.

Key words : *Germination, Seed longevity, Soybean,Variability*

Introduction

Soybean (*Glycine max* (L.)Merrill) is a legume species; classified as an oilseed rather than a pulse. Soybean (2n=40) belongs to Fabaceae family and be-lieved to have originated in Northeastern China and distributed in Asia, USA, Brazil, Argentina. The crop is referred as 'greater bean' or 'yellow bean' also. Soybean is recognized across the growing countries in terms of total production and interna-tional trade as it represents 58% of world oilseed production with a production of 258.8 million met-ric tons (MMT); majorly contributed by United States (35%) followed by Brazil (27%), Argentina (19%), China (6%) and India (4%). In India, it occupies 10.3Mha of area with 11MMT of production and productivity of 1070kg ha^{-1}.

High quality seed that provides adequate plant stand is the basis for profitable production and ex-pansion of soybean crop. In order to increase the production of soybean, high quality and disease free seeds must be made available to the farmers. Loss of viability and vigour under high temperature and relative humidity conditions is a common phenom-enon in many crop seeds, but it is well pronounced in soybean.

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Seed longevity is a complex trait like seed yield, having controlled by many other component traits which need to be studied for further understanding. One of the major constraints in soybean cultivation is the non-availability of quality seeds at the time of sowing. However, a few varieties have been identi-fied recently that have superior seed longevity. Studies of seed longevity under conventional or op-timal storage conditions would take more time to complete, so accelerated ageing or controlled dete-rioration (CD) conditions are utilized to speed the loss of viability in recent studies. Development of superior varieties with high seed longevity depends on the presence and extent of the genetic variability for the desirable seed longevity characters. Thus, present work aims to study the extent of their ge-netic variability for seed yield and other component traits which enhances seed longevity in soybean. Soybean seed germination and vigour potential is short lived as compared to other grain crops and it is often reduced prior to planting time (Nkang and Umoh, 1996)

Materials and Methods

Plant material and experimental design

The experimental material used in the study com-prised of two hundred and twenty five genotypes of soybean including indigenous and exotic collections, released varieties in India and mutant lines of vari-eties JS-335 and KHSb-2, collected from Nucleus Seed Production/Breeder Seed Production Unit, UAS Dharwad, which are presently being main-tained at All India Co-ordinated Research Project on Soybean, University of Agricultural Sciences, Dharwad. The experimental genotypes was laid out in Lattice Design (15×15) with two replications in two rows each of 2 m length with spacing of 45 cm between rows and 10 cm between the plants. The recommended package of practices was followed for raising ahealthy crop.

Germination test

Germination test was conducted by adopting be-tween paper method. Seeds were incubated at slant-ing position in Walk-in germination room in growth cabinets. The temperature of 25 ± 1^{o}C and relative humidity (RH) of 95% was maintained. Germination (%) was recorded on the basis of normal seedlings (ISTA 1993).

Accelerated aging

The seed material was subjected to accelerated age-ing by controlled deterioration test. The chamber was sterilized with alcohol to prevent the fungal contamination. Individual genotypes were taken in separate petri plates, incubated in temperature and relative humidity (RH) control chamber at 40^{o}C tem-perature and 94 to 100% RH for 72 hours continu-ously (ISTA, 1993).

Seed coat permeability

The permeability was measured as amount of water absorbed per unit of seed weight and expressed as percent water absorbed. For this purpose, two rep-licates of 25 seeds were weighed (W1) and then soaked in 50 mL distilled water for 1hr. Excess of water was drained out and thoroughly cleaned with blotting paper and weighed immediately (W2). The rate of seed coat permeability was calculated as% water absorbed (ISTA 1993).

$$\text{Water absorbed (\%)} = \frac{(W2 — W1)}{W1} \times 100$$

Where, W1 = Initial weight, W2 = Final weight

Electrical conductivity

Five grams of seeds were weighed in two replica-tions from each selected genotypes and soaked in 50 mL distilled water in a beaker and kept at 25±1ºC temperature. 50 mL of distilled water was used as control. After 24 hours of soaking, the leachates were stirred using a glass rod, poured into another beaker and the volume was made up to 25 mL by adding distilled water. The electrical conductivity of the leachates was measured using digital conductiv-ity meter and the mean of two replicates were ex-pressed in dSm^{-1} (ISTA 1993).

The characters studied were days to 50 percent flowering, plant height, number of branches per plant, days to maturity, number of pods per plant, number of seeds per pod, seed test weight, protein content, oil content, seed yield per plant and seed yield per hectare. For seed longevity study, seed germination test was carried out before and after the accelerated ageing test and percent reduction in ger-mination was recorded as a measure of seed longev-ity along with seed coat permeability and electrical conductivity. Analysis of variance, phenotypic vari-ances, genotypic variances and correlations were estimated following Singh and Chaudhary (1979).

Results and Discussion

The present investigation was carried out using 225 genotypes, for elucidating nature and extent of variation, for yield, yield component and seed qual-ity traits. The mean sum of squares due to various sources of variation for 16 characters *viz.*, days to 50 per cent flowering, plant height, number of branches per plant, days to maturity, number of pods per plant, number of seeds per pod, seed test weight, protein content, oil content, seed yield per plant, yield per hectare, initial germination, final germina-tion, seed coat permeability, electrical conductivity and germination reduction after accelerated ageing are presented in Table 1.

The variation due to genotypes was significant for all the characters under study both at 5 and 1 per cent probability levels, except for number of seed per pod and oil content which were significant only at 5 per cent probability level. Variability was maxi-mum to seed yield per ha, plant height, number of pods per plant, test weight, initial germination, final germination, seed coat permeability, electrical con-ductivity and germination reduction. A similar find-ing was reported for plant height, number of pods per plant by Aravind *et al*., (2006) and Parameshwar *et al*., (2006). For days to maturity, seed yield per plant and days to 50% flowering moderate variabil-ity was seen. The characters like number of branches, number of seeds per pod, protein content and oil content showed low range of variability. Therefore, it can be concluded that there is still scope for increasing the oil content and yield of present genotypes.

To examine breeding utilities, genetic parameters were studied for the experimental material. It was observed that the plants exhibited significant vari-ability for yield and longevity and their attributing traits. The estimates depicting the genetic variability including mean, range, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2), genetic advance (GA) and genetic advance mean (GAM) of all the traits are calculated (Table 1).

The PCV was higher in magnitude than the GCV in respect to all the characters. The characters plant height, number of pods per plant, test weight, seed yield per plant, seed yield per hectare, final germi-nation, seed coat permeability, electrical conductiv-ity and germination reduction showed high PCV and GCV, while number of branches per plant and initial germination showed moderate PCV and GCV, whereas days to 50 percent flowering, days to maturity, number of seeds per pod, protein content

Table 1. Estimation of mean sum of squares of genotypes, range, mean and different genetic parameters for various quantitative traits of soybean

Sl. No.	Variables	Mean sum of squares genotype	Range	Mean	GCV	PCV	h^2	GA	GAM
1.	Days to 50% flowering	24.64**	35.5-52.5	42.48	8.17	8.36	95.53	6.99	16.45
2.	Plant height (cm)	440.00**	17.74-102.86	45.19	32.59	33.06	97.18	29.91	66.18
3.	No. of branches per plant	0.79**	2.5-5.7	3.76	14.86	18.37	65.48	0.93	24.78
4.	Days to maturity	39.26**	73-113	88.27	4.94	5.1	93.63	8.69	9.84
5.	No. of pods per plant	345.23**	24.1-101.2	53.74	23.76	25.11	89.55	24.9	46.33
6.	No. of seeds per pod	0.08*	1.95-3.25	2.46	7.03	9.07	60.00	0.28	11.22
7.	Seed test weight (g)	15.55**	5.5-21	12.64	21.61	22.5	92.25	5.41	42.75
8.	Protein content (%)	3.09**	36.55-44.85	39.39	2.99	3.31	81.5	2.19	5.56
9.	Oil content (%)	2.19*	12.6-20	17.74	5.68	6.12	86.1	1.93	10.86
10.	Seed yield per plant (g)	39.19**	4-27.4	15.27	28.07	29.87	88.3	8.3	54.33
11.	Seed yield (kg/ha)	1085093.76**	513.89- 4377.78	2057.04	33.39	38.07	76.93	124.1	60.33
12.	Initial germination (%)	370.14**	25-100	82.72	15.27	17.26	81.44	23.96	28.95
13.	Final germination (%)	649.90**	10 - 93	47.76	36.7	37.82	94.12	17.74	73.34
14.	Seed coat permeability (%)	528.30**	9.96-135.65	50.27	30.09	34.11	79.75	28.16	56.03
15.	Electrical conductivity (dS m^{-1})	0.60**	0.42-2.87	1.33	40.09	41.45	95.90	1.09	81.89
16.	Germination reduction (%)	663.11**	2.11-87.62	42.88	42.03	44.61	88.76	34.27	81.57

*significant at 5% **significant at 1%

and oil content showed low PCV and GCV. The narrow difference between the PCV and GCV observed here indicated the lesser influence of environment for these traits. This is other indication of genetic improvement for these traits to be effective through selection.

The partitioning of variance revealed that high broad sense heritability and genetic advance as per cent of mean were recorded for plant height, num-ber of branches per plant, number of pods per plant, test weight, seed yield per plant, seed yield per hect-are, initial germination, final germination, seed coat permeability, electrical conductivity and percent reduction in germination, indicating the additive mode of gene action hence would respond to intense selection exercise and would result in improvement in soybean for these characters.

High heritability and moderate genetic advance as percent mean was observed for days to 50 per cent flowering and oil content. However, days to maturity and protein content showed high heritabil-ity and low genetic advance as percent mean, indi-cating involvement of non-additive genes, hence heterosis breeding involving population improve-ment methods may be useful for improvement of these characters. Whereas, number of seed per pod showed moderate heritability and moderate genetic advance as percent mean indicating additive gene effects.

The ultimate aim of a plant breeder is to alter the genetic makeup of the plant in order to improve the seed yield. However, since poor seed longevity is the major problem in soybean, higher seed yield with good seed longevity is of greater importance. Depending upon the positive and negative effect of each interacting traits, the seed longevity may either be high or low because interaction of traits at genetic level results in different gene combination. For a notable selection for higher yield with good seed longevity, a thorough understanding of yield con-tributing traits, inter-relationship among yield and yield attributes and the same with seed longevity traits is essential.

In the present study number of branches per plant, number of pods per plant and test weight showed positive and significant correlation with seed yield per plant, the results obtained from this study is in confirmation with the results of Faisal *et al.* (2011) and Shivakumar (2011). Similarly, the phe-notypic and genotypic correlation of seed longevity in terms of germination reduction (%) in the present

Table2. Genotypic correlation co-efficient for different quantitative traits in soybean

Traits	Days to 50% flowering	Plant height (cm)	No. of branches per plant	Days to maturity plant	No. of pods per	No. of seeds per pod	Test weight (g)	Protein content (%)	Oil content (%)	Seed yield per plant (g)
Days to 50% flowering	1	0.561**	0.362**	0.588**	0.358**	-0.091**	-0.554**	0.474**	-0.474**	-0.039
Plant height (cm)		1	0.363**	0.468**	0.315**	0.002	-0.676**	0.369**	-0.272**	-0.121*
No. of branches per plant			1	0.265**	0.677**	-0.154**	-0.346**	0.195**	-0.202**	0.423**
Days to maturity				1	0.267**	-0.077**	-0.418**	0.507**	-0.41**	-0.091**
No. of pods per plant					1	-0.080**	-0.331**	0.209**	-0.270**	0.602**
No. of seeds per pod						1	-0.028**	-0.075**	0.066**	-0.065**
Test weight (g)							1	-0.414**	0.416**	0.227**
Protein content (%)								1	-0.807**	-0.101*
Oil content (%)									1	0.064*

*significant at 5% **significant at 1%

study was positive and significant with test weight, seed coat permeability and electrical conductivity (Smith, 2000; Kuchlan *et al.,* 2010). This suggests that while selection is made improvement of seed yield these characters can also be kept in mind provided the character should show high variability, which is basis for the selection (Table 2 and 3).

While estimating the associations among the yield, seed longevity and their attributing traits, it was observed that, number of branches per plant had highly significant and positive association with seed yield per plant which was also positively asso-ciated with days to 50 percent flowering, plant height, days to maturity, number of pods per plant and protein content however, it has exhibited nega-tive association with number of seeds per pod, test weight and oil content. Hence, these characters can also be emphasized for indirect selection to yield improvement in soybean. Number of pods per plant showed significant and positive association with days to 50 per cent flowering, plant height, days to maturity and protein content but number of seed per pod was positive and significant at phenotypic level only. However, it showed significant negative correlation with test weight and oil content. Hence, number of pods per plant can be increased by select-ing for plant height and protein helps in increasing seed yield per plant indirectly with high protein content.Test weight with characters viz., days to 50 per cent flowering, plant height, number of branches per plant and days to maturity, Number of pod per plant, exhibited significant negative correlation. Since test weight is highly significant and positively correlated with yield, selection for this trait ulti-mately helps to make improvement in yield.

Similarly, for seed longevity, component traits like test weight had positive and significant associa-tion with per cent reduction in germination which was also positively associated with seed coat perme-ability, electrical conductivity and oil content, al-though test weight is negative and significantly cor-related with initial germination and protein content. So selection for low test weight helps to bring im-provement in seed longevity by decreasing the re-duction in the germination. Seed coat permeability was positive and significantly correlated with elec-trical conductivity and test weight but it was posi-tive and significantly associated with protein con-tent only at genotypic level (Kuchalan *et al.,* 2010). Though, seed coat permeability had significant negative association with oil content. Therefore, se-lection for poor seed coat permeability and associ-ated traits helps to improve the seed longevity indi-rectly. Electrical conductivity exhibited significant and positive correlation with seed coat permeability and test weight. Whereas, negative and significant association was noticed with initial germination. (Vieira *et al.,* 1999; Chachalis and Smith, 2000).

It is worth while to identify superior genotypes compared to the best check. The potential genotypes which performed better than the best check (Table 4). The genotypes were selected considering both initial and final germination per cent which satisfy the rule of seed certification, having minimum seed germination of 70 per cent and also by considering the germination reduction compared with the best check. The genotype PK 7379 showed highest yield (3708.33 kg/ha) with least reduction in germination (3.95%) with more number of pods per seed (69) and high protein content (40.4) followed by PI 284815, PI 204336, CO-1 and JS 79-307.

From the present investigation it is concluded

Table 3. Genotypic correlations for seed longevity related traits in soybean

Traits	Protein content (%)	Oil content (%)	Moisture (%)	Test weight (g)	Initial germination (%)	SCP (%water absorbed)	EC (dS m^{-1})	Germination reduction (%)
Protein (%)	1	-0.707**	-0.386**	-0.367**	0.076**	0.083**	0.030	0.018
Oil (%)		1	0.582**	0.317**	-0.114**	-0.086**	0.000	-0.043*
Moisture (%)			1	0.133**	-0.057**	0.030	-0.022	0.025
Test weight				1	-0.396**	0.253**	0.289**	0.252**
Initial germination (%)					1	-0.064	-0.360**	-0.009
SCP (%water absorbed)						1	0.451**	0.283**
EC (dSm^{-1})							1	0.289**

*significant at 5% **significant at 1%

Table4. Potential genotypes for high yield with good seed longevity

Genotype	% reduction in germination	Days to 50% flowering	Plant height (cm)	No. of branches per plat	Days to maturity	No. of pods per plant	No. of seed per pod	Test weight (g)	Protein content (%)	Oil content (%)	Seed yield per plant (g)	Seed yield (kg/ha)
PK 7379	3.95	42.50	32.67	4.20	87.50	69.00	2.20	14.50	40.40	17.40	25.90	3708.33
PI 284815	4.49	42.50	50.15	4.30	87.50	62.00	2.90	13.50	40.00	17.10	18.10	3041.67
PI 204336	7.50	43.50	43.70	4.30	87.50	57.70	2.85	12.00	39.80	17.15	19.40	3497.22
CO-1	11.39	39.50	49.05	3.80	89.00	48.10	2.40	16.50	40.30	17.95	22.20	3586.11
Checks												
JS 79-307	11.54	42.50	41.43	3.90	89.00	63.10	2.35	12.00	38.10	17.25	18.70	3344.44
Birsa Soy 1	13.64	39.50	29.50	4.00	88.00	48.40	2.25	13.00	39.00	19.30	13.50	1730.56
JS 93-05	17.14	37.00	41.00	4.20	84.50	35.80	2.70	11.00	39.10	18.65	11.10	2105.56
JS-335	20.22	38.00	40.60	3.20	81.00	49.55	2.40	14.50	37.95	18.60	11.60	2555.56
± SEm	4.44	0.53	1.77	0.29	0.80	3.08	0.10	0.56	0.40	0.29	1.10	266.01
CD at 5%	12.38	1.48	5.02	0.79	2.21	8.74	0.33	1.59	1.08	0.79	3.09	760.28
CD at 1%	16.33	1.95	6.62	1.04	2.91	11.52	0.44	2.10	1.42	1.04	4.08	1002.77

that the genotypes exhibited a wide range of vari-ability for all of the traits. Some genotypes possessed desirable genes for more than one character; geno-types identified with good seed longevity can be ef-fectively utilized in the hybridization programme to develop good hybrids with maximum seed longev-ity which is the major bottleneck in soybean cultiva-tion in tropical region. The traits like seed coat per-meability and electrical conductivity are effectively amenable as a component trait for selection exercises for the improvement of seed longevity.

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