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Character association for seed yield and seed longevity in soybean

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Abstract
The extent of genetic variability and correlation for yield and seed quality traits in 24 genotypes of soybean was evaluated during rainy 2014. Wide genetic variability with high heritability and genetic advance was observed for seedling dry weight, SVI II, Seed Yield/ha and clusters/plant indicating additive gene action with further scope to enrich variation for these characters. The seed yield/ha has shown significant positive correlation with days to 50% flowering, plant height, clusters/plant, pods/plant and 100 seed weight. SVI I has shown positive association with 100 seed weight, germination %, seedling length and seedling dry weight while SVI II for 100 seed weight, germination %, Seedling dry weight and SVI I. genotypes GP 13, Basar, A-3-1 and RKS 18 have shown superior performance in terms of seed longevity and seed yield.

Keywords: Soybean, variability, correlation, seed quality

Introduction
Soybean occupies a prominent place in the world as it contributes to 25% of global vegetable oil production and two third of the world's protein concentrate for livestock feeding. The major soybean growing nations are United States of America, Brazil and Argentina accounting to 80% of soybean supply. India ranks 5th in soybean production in the world. Soybean occupied an area of 11.6 mha with a production of 8.6 million tones and productivity of 738 kg/ha during the year 2015-16 (SOPA).

The major portion of soybean production is in temperate region but there is a tremendous potential to expand into tropics but major constraint of soybean cultivation in tropics is rapid deterioration of seed with poor storability, leading to non availability of quality seed to farmers. Soybean seed germination and vigour potential is short lived as compared to other crops and it is often reduced prior to planting time (N Kang and Umrah, 1996) [4]. Only few varieties with superior longevity are identified.

Hence it is necessary to develop varieties with greater seed longevity which depends on the presence and extent of genetic variability in the crop for seed longevity. The present study thus aims to identify superior soybean genotypes with higher seed longevity and superior yield which can be further used in the breeding programme for improvement of soybean.

Material and Methods
The experiments was conducted during *rainy* 2014 at RS&RRS, Rudrur, Nizamabad District, Telangana state which is located at 77^0 88 East and 18^0 58 North at an elevation of 404m above mean sea level. The soil pH at test location ranged from 7.5-8.0 and the experimental material involved twenty four diverse genotypes of soybean collected from ARS, Adilabad, Telangana. The experiment was laid out in Randomized Block Design with two replications. Each genotype is grown in 4 rows of 4m length and at a spacing of 30 X 10 cm. Recommended package of practices were followed to raise a healthy crop. Observations were recorded in five randomly selected plants from each plot for the traits plant height (cm), number of branches/plant, number of clusters/plant, number of pods/plant and 100 seed weight while days to 50% flowering and seed yield was recorded on whole plot basis. The freshly harvested seed of these genotypes was stored in ambient conditions in cloth bags. The seeds of 24 genotypes of Soybean were tested for various seed quality parameters such as percent germination, total seedling length, seedling dry weight, Seedling vigour index I and Seedling vigour index II at 8 months after storage. Germination percentage was tested using between paper method (ISTA, 1985) where in 100 seeds were placed in each replication.

$$\text{Germination Percentage} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds planted}} \text{ X } 100$$

Ten seedlings were selected at random in each replication from germination test for recording seedling length (in cm) and later dried in hot air oven at 80 ^{0}C for two days and seedling dry weight was recorded (in g). Seedling vigour index (SVI I) was calculated using the formula of Abdul Baki & Anderson (1973).

SVI on length basis (SVI I) = Average seedling length X Germination Percentage

SVI on dry weight basis (SVI II) = Average seedling dry weight X Germination Percentage

Standard statistical procedures were used for analysis of variance, genotypic and phenotypic coefficient of variation, heritability and genetic advance. The genotypic and phenotypic correlation coefficients were compared using genotypic and phenotypic variances and covariances.

Results and Discussion

The analysis of variance indicated the existence of variability for all the characters among 24 genotypes (Table: 1). The mea n sum of squares due to genotypes was high for all the characters. This is in agreement with Ramyashree *et al* (2016) [7], Rens and Rao *et al* (2013) [8] and Zafar *et al* (2008) [11]. Information on variability is presented in Table: 2. Variability was maximum for seedling vigour Index I and II, seed yield / ha, pods/plant and Plant height. A similar finding was reported for plant height, pods/plant and seed yield/ha by Naik *et al* (2016) [6]. Low range of variability was reported by days to 50% flowering, branches/plant, 100 seed weight, seedling length and seedling dry weight. The estimates of variability indicated that PCV was higher than GCV for all the characters under study.

High (>20%) phenotypic variance (Plant height, Pods / plant, seed yield/ha, Germination %, SVI I and SVI II) and coefficient of variation (Branches/plant, clusters/plant, pods/plant, Seed Yield/ha) in the present study was noticed to be essentially associated with genetic variability and coefficient of variation of the particular trait, indicating existence of high genetic variability and minimal influence of environment for these traits in the material. Hence selection for these characters based on phenotype would also be effective in improvement of these traits. Further high (>20%) estimates of GCV and PCV recorded for pods /plant and seed yield/ha are in conformity with Naik *et al*. (2016) [6]. Moderate (10-20%) GCV and PCV estimates were recorded for plant height, branches/plant, 100 seed weight, seedling dry weight and SVI II. Low (<10%) estimates of genotypic and phenotypic variance and coefficient of variation was observed for days to 50% flowering, branches /plant, 100 seed weight and seedling length. Seed yield/ha followed by clusters/plant, branches/plant and plant height recorded highest ECV indicating more influence of environment on these characters hence caution may be exercised while selecting these traits. The difference between PCV and GCV was very small for days to 50% flowering, germination %, seedling length, seedling dry weight, SVI I and SVI II after storage indicating that these characters are less influenced by environment and genetic factors play a major role in expression of these characters.

High heritability (60%) was recorded for days to 50% flowering, pods/plant, seed yield/ha, germination %, seedling length, seedling dry weight, SVI I and II. The results of Genetic advance as percent mean (>20%) was recorded in branches/plant, pods/plant, seed yield/ha, seedling dry weight, SVI I and SVI II. Moderate (10-20%) Genetic advance as percent mean was reported for plant height, clusters/plant, 100 seed weight, germination % and seedling length. Further low (<10%) Genetic advance as percent mean was reported for days to 50% flowering.

High heritability coupled with high genetic advance was reported for seedling dry weight, SVI II, Seed Yield/ha and clusters/plant indicating additive gene action with further scope to enrich variation for these characters. Similar results for seed yield/ha was reported by Naik *et al* (2016) [6] while for seed quality parameter like SVI II by Ramyasree *et al* (2016) [7]. High heritability accomplished with low Genetic advance was reported for seedling length, germination %, days to 50% flowering suggesting the role of non additive gene action. A similar result for days to 50% flowering was reported by Aditya *et al* (2011) [2]. This indicates the role of heterosis breeding involving population improvement methods for improvement of these characters.

Yield is a complex character and is end product of multiplicative interaction between various yield components (Grafeus, 1956) [3]. Hence information of association of yield and its component characters is very much essential for any crop improvement programme. The genotypic and phenotypic correlation coefficients for yield and yield components are presented in Table: 3. The genotypic correlation coefficient was higher than phenotypic correlation coefficient. The seed yield/ha has shown significant positive correlation with days to 50% flowering, plant height, clusters/plant, pods/plant and 100 seed weight. Similar results for pods/plant were reported by Naik *et al* (2016) [6] and Shiva kumar *et al* (2011) [9]. The phenotypic and genotypic correlation for seed longevity in terms of SVI I and II in this study was positive and significant, In case of SVI I for 100 seed weight, germination %, seedling length and seedling dry weight while for SVI II for 100 seed weight, germination %, Seedling dry weight and SVI I. Similar results of association of 100 seed weight for seed longevity was reported by Kulchan *et al* (2010) [5]. While estimating association of seed yield/ha, plant height has shown higher positive and significant association which is also positively associated with days to 50% flowering, hence indirect selection for this character will result in yield improvement of soybean. Similarly pods/plant have shown positive association with days to 50% flowering, plant height, branches/plant and cluster/plant hence indirect selection will ultimately help in improvement of yield.

The genotype superior in performance than the checks is presented in Table: 4. The genotypes showing high germination % after 8 months of storage than the checks are enlisted. The genotype GP 13 recorded an yield of 3479 kg/ha with a germination % of 90.5 after 8 months of storage, followed by Basar (2958 kg/ha, 90.5%), A-3-1 (2791 kg/ha, 91) and RKS 18 (2475 kg/ha, 90.5)

The genotypes showed lot of variability for seed longevity and yield traits. Some genotypes had desirable genes for both longevity and yield. As seed longevity is the major bottleneck in soybean cultivation, genotypes with good seed longevity can be utilized in the breeding programme to develop new varieties with maximum seed longevity.

Table 1: Analysis of variance (ANOVA) for 12 characters in 24 soybean genotypes

Character	Mean sum of squares		
	Replicates (df=1)	Treatments (df=23)	Error (df=23)
Days to 50 % flowering	0.688	3.774***	0.296
Plant Height (cm)	59.853	122.388*	53.09
Branches per plant	0.013	5.068**	1.558
Clusters per plant	13.868	21.795*	9.673
pods per plant	127.075	406.14***	51.435
100 seed weight (g)	1.21	4.418*	1.79
Seed yield per ha (kg/ha)	0.004	120.911***	26.508
Germination (%)	4.083	75.736***	1.562
seedling Length (cm)	0.13	1.341***	0.008
Seedling dry weight (g)	0	0.098***	0.001
Seedling Vigour Index I	2953.332	18321.88***	270.505
Seedling Vigour Index II	18.213	1093.925***	14.05

Table 2: Grand mean, Variation, Heritability and genetic advance for yield and seed quality characters in 24 soybean genotypes

Genetic Parameters	Grand Mean	Vp	Vg	PCV%	GCV%	ECV%	h^2b%	GAPM
Days to 50 % flowering	39.8125	2.0353	1.7391	3.5834	3.3124	1.367	85.45	6.3076
Plant Height (cm)	51.4583	87.7388	34.6489	18.2029	11.439	14.1596	39.49	14.8083
Branches per plant	8.7083	3.3127	1.755	20.9004	15.2126	14.3319	52.98	22.8097
Clusters per plant	18.8458	15.7337	6.061	21.0475	13.0634	16.5028	38.52	16.7025
pods per plant	59.0604	228.7878	177.3526	25.6106	22.5487	12.1432	77.52	40.897
100 seed weight (g)	11.5613	3.1042	1.3138	15.2394	9.9143	11.5735	42.32	13.2869
Seed yield per ha (kg/ha)	27.3352	73.7092	47.2013	31.4079	25.1336	18.835	64.04	41.4322
Germination (%)	83.5417	38.6486	37.087	7.4416	7.2897	1.4958	95.96	14.7102
seedling Length (cm)	11.3925	0.6748	0.6665	7.2104	7.166	0.7984	98.77	14.6712
Seedling dry weight (g)	1.5111	0.0498	0.0484	14.7698	14.5531	2.5209	97.09	29.5395
Seedling Vigour Index I	951.4131	9296.192	9025.687	10.1341	9.9855	1.7287	97.09	20.2687
Seedling Vigour Index II	126.6287	553.9881	539.9373	18.5874	18.3501	2.9602	97.46	37.3188

Vp= Phenotypic variance, Vg= Genotypic variance, PCV (percent)= Phenotypic coefficient of variation, GCV (percent)= Genotypic coefficient of variation, ECV (percent)= Environment coefficient of variation, h^2b (percent)= heritability in broad sense, GAPM= Genetic advance as percent mean.

Table 3: Phenotypic (r_p) and Genotypic (r_g) correlation coefficients for yield and seed quality characters in soybean genotypes

Traits		Days to 50% flowering	Plant Height (cm)	Branches per plant	Clusters per plant	pods per plant	100 seed weight (g)	Seed yield per ha (kg/ha)	Germination (%)	seedling Length (cm)	Seedling dry weight (g)	Seedling Vigour Index I	Seedling Vigour Index II
Days to 50% flowering	r_p	1	0.37748**	0.1208	0.3920**	0.4985***	0.3833**	0.4601***	-0.3444*	-0.1187	-0.2652	-0.3333*	-0.3542*
	r_g	1	0.6869***	0.1957	0.5984***	0.5859***	-0.5898***	0.5964***	-0.3404*	-0.1299	-0.2820	-0.3355*	-0.3661*
Plant Height (cm)	r_p		1	0.3224*	0.4634**	0.4525**	0.0799	0.4988***	-0.4670**	0.1249	-0.0717	-0.258	-0.2418
	r_g		1	0.4916***	0.9675***	0.6940***	0.1626	0.7411***	-0.7851***	0.1918	-0.1058	-0.4417***	-0.3905**
Branches per plant	r_p			1	0.276	0.2877**	0.2336	0.0481	-0.0272	0.2529	0.0857	0.1686	0.0556
	r_g			1	0.5450***	0.2596	0.239	-0.0292	-0.0163	0.3448*	0.1355	0.2458	0.0965
Clusters per plant	r_p				1	0.8526**	0.1693	0.1948	-0.1279	0.1467	0.0856	0.0112	0.024
	r_g				1	1.0989***	0.0509	0.5541***	-0.2321	0.1912	0.0918	-0.0355	-0.0123
pods per plant	r_p					1	0.0381	0.2416	-0.2210	0.0929	-0.0406	-0.0954	-0.1161
	r_g					1	0.02	0.3522*	-0.2736	0.1072	-0.0518	-0.1234	-0.1440
100 seed weight (g)	r_p						1	0.1636	-0.3470*	0.1709	0.0735	-0.1276	-0.0794
	r_g						1	0.3167*	-0.4193**	0.2205	0.0732	-0.1393	-0.1072
Seed yield per ha (kg/ha)	r_p							1	0.1343	0.37668	0.3804**	0.3359*	0.3604*
	r_g							1	0.2228	0.4024**	0.5347***	0.4595**	0.5207***
Germination (%)	r_p								1	-0.0716	0.2892*	0.6896***	0.6322**
	r_g								1	-0.0736	0.2982*	0.6831***	0.6359***
seedling Length (cm)	r_p									1	0.2875*	0.6715***	0.2041
	r_g									1	0.2856*	0.6768***	0.2016
Seedling dry weight (g)	r_p										1	0.4216**	0.9235***
	r_g										1	0.4272**	0.9253***
Seedling Vigour Index I	r_p											1	0.6160***
	r_g											1	0.6151***
Seedling Vigour Index II	r_p												1
	r_g												1

Table 4: Superior genotypes for high seed yield and seed longevity.

Genotype	Germination (%) 8 months after Storage	Days to 50 % flowering	Plant Height (cm)	Branches per plant	Clusters per plant	pods per plant	100 seed weight (g)	Seed yield per ha (kg/ha)
GP 13	90.5	40	46.7	6.7	20	59.3	9.925	3479
Basar	90.5	41	57.9	10.9	21.1	63.4	11.82	2958
A-3-1	91	41	47.8	11.2	18.5	55.5	11.945	2791
RKS 18	90.5	38	40	6.5	18.8	59.3	13.24	2479
Checks								
JS 335	88	37.5	38.5	7.6	13.9	38.2	12.39	2500
JS 93-05	89.5	35.5	42.5	6.5	11.8	35.3	12.39	2125
CV	1.494	1.367	14.159	14.332	16.503	12.143	11.573	18.835
CD 5%	2.585	1.126	15.073	2.582	6.434	14.836	2.768	10.651

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