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Riemonsha M Syiem
Department of Genetics and Plant Breeding, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema, Nagaland, India

HP Chaturvedi
Department of Genetics and Plant Breeding, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema, Nagaland, India

Pankaj Shah
Department of Genetics and Plant Breeding, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema, Nagaland, India

MB Sharma
Department of Genetics and Plant Breeding, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema, Nagaland, India

Corresponding Author:
HP Chaturvedi
Department of Genetics and Plant Breeding, School of Agricultural Sciences & Rural Development, Nagaland University, Medziphema, Nagaland, India

Genetic variability and correlation analysis for seedling vigour traits in soybean [*Glycine max* (L.) Merrill] genotypes

Riemonsha M Syiem, HP Chaturvedi, Pankaj Shah and MB Sharma

Abstract
A total of ten genotypes of soybean were evaluated in the laboratory of the Department of Genetics and Plant Breeding, School of Agricultural Research and Rural Development, Nagaland University, Medziphema Campus, Nagaland during the year of 2021. The experiment was carried out following a Completely Randomized Design in three replications. The analysis of variance revealed significant differences among genotypes for all the characters studied, indicating high degree of variability in the material. The high genotypic and phenotypic coefficient of variation was observed for seedling vigour index II, germination percentage, seedling vigour index vigour I and dry root weight at 20 days. In the present study, it can be concluded that characters such as seedling vigour index I, seedling vigour index II, emergence of plumule and germination percentage have high heritability estimates coupled with high genetic advance indicating the role of additive genes effects in controlling these traits and can be improved by applying phenotypic selection. Correlation studies indicated that emergence of plumule, germination percentage, shoot length at 20th days, fresh shoot weight, dry root weight at 20th days, dry shoot weight at 20th days and seedling vigour index I have strong positive correlation with seedlings vigour index II at genotypic level indicating relative utility of these traits for selection.

Keywords: Soybean, genotype, seedling vigour, genetic variability, correlation

Introduction
Soybean [*Glycine max* (L.) Merrill] is known for its highly valued protein and oil. It contains a high amount of quality protein (42 per cent) and 20 per cent oil (Gopalan *et al*., 1994) [6] rich in lycine and vitamin A, B and D. Soybean meets the nutritional needs of humans (He and Chen, 2013; Malek *et al*., 2014; Ghosh *et al*., 2014) [9, 11, 7]. Besides to its use in food, feed, and industrial applications it enriches the soil by fixing nitrogen in symbiosis with bacteria. The farming communities in the North-eastern region grow soybean in small areas to meet their domestic requirements of soybean. There are bright prospects for popularizing this highly remunerative crop in the Northeastern parts of India.
In the development of new cultivars with good agronomic attributes, breeders should consider the seed-related variables, since new cultivars with good germination capacity are highly desired. The success of germination, seedling establishment and later growth and development of every agricultural crop depends on many factors among them seed quality is one. Seed vigour is one of the essential characters of seed quality, impacting potential seed germination, seedling growth, seed longevity and tolerance to adversity (Sun *et al*., 2007) [13]. High vigour can significantly improve the speed and uniformity of germination and good germination leads to uniform seed emergence, good crop performance and even high yields under varying conditions (Foolad *et al.*, 2007) [5]. Low soybean yields have been reported to be affected by several factors including poor-quality seeds with low seed and seedling vigour. Highly vigorous seeds are prerequisites for a high field emergence rate and vigorous seedlings, hence, determination of seed vigour is very important before sowing. Therefore, the present study was carried out to determine the extent of genetic variability and correlation analysis for seedling vigour traits.

Materials and Methods
The present investigation was carried out in the laboratory of Department of Genetics and Plant Breeding, School of Agricultural Research and Rural Development, Nagaland University, Medziphema Campus, Nagaland during the year of 2021.

It has a sub tropical climate and is located at 23˚ 24'49" N latitude and 90˚33'04" S longitude at an altitude of 305 metres above sea level. The experiment was carried out following a Completely Randomized Design in three replications with ten genotypes. Seeds of ten genotypes namely AMS 20-19, JS 21-71, RVSM 2011-35, AMS 100-39, MAUS 1620, SL 1213, NRC 149, Dsb33, NRC 136, NRC SL 2 of soybean were collected from AICRP Soybean, SASRD Medziphema, Nagaland and used in the present investigation. Data were recorded on ten genotypes for twelve characters *viz*., emergence of radicle, emergence of plumule, germination percentage, root length at 20th days, shoot length at 20th days, fresh root weight at 20th days, fresh shoot weight at 20th days, dry root weight at 20th days, dry shoot weight at 20th days, seed weight, seedling vigour Index I, seedling vigour index II. The analysis of variance was carried out according to Panse and Sukhatme (1957) [12] by using the mean performance of the genotypes. The phenotypic, genotypic and environmental coefficient of variation was calculated according to Burton and De Vane (1953) [3]. Heritability was calculated according to Allard (1960) [2]. Genetic advance possible through selection was calculated according to Johnson *et al*. (1955) [10]. Phenotypic and genotypic correlation coefficients were worked out as suggested by Al-Jibouri *et al.* (1958) [1].

Result and Discussion

Significant differences were recorded among ten genotypes in all studied characters indicating high degree of variability in the material. The estimates of phenotypic coefficient of variation (PCV) were higher than those of genotypic coefficient of variation (GCV) for all the traits indicating the role of environmental variance in the total variance (Table-1). According to Deshmukh *et al*. (1986) [4] GCV and PCV values greater than 20% are regarded as high, whereas values less than 10% are considered to be low and values between 10% and 20% to be medium. Based on this, the present study showed medium and high GCV and PCV for all the character under study. The highest GCV and PCV were recorded for seeding vigour I, seedling vigour index II, emergence of plumule, and germination percentage.

A fair measure of efficiency of selection for any quantitative traits can be derived from the character under consideration because heritability in a broad sense is the ratio of genotypic variance to the total phenotypic variance. But reliability depends not only on heritability, but it also should be accompanied by genetic advances as well (Johnson *et al.* 1955) [10]. High heritability coupled with high genetic advance shows that progress can be made through selection. Heritability is actually considered to be low if it is less than 30 percent, moderate between (30-60 percent0 and high if it is more than 60 percent (Johnson *et al.* 1955) [10]. The range of genetic advance as percent of mean is classified as low if it is less than 10 percent, moderate between (10-20 percent) and high if more than 20 percent (Johnson *et al.* 1955) [10]. In the present study, high estimates of heritability and genetic advance were obtained for 100 seed weight, seedling vigour I, emergence of plumule and germination percentage (Table- 1). Thus selection for these traits is likely to accumulate more additive genes leading to further improvement of their performance and these traits may be used as selection criteria in soybean breeding program.

Correlation coefficient is a statistical measure which is used to find out the mutual relationship between various plants characters on which selection can be based for genetic improvement in yield. Correlation coefficient enables to identify characters or combinations of characters, which might be useful indicator of high yield. Correlation studies provide better understanding of yield components which helps in plant breeder during selection (Johnson *et al.* 1955) [10]. Therefore in the present study, correlation between twelve characters was studied in all possible combinations at phenotypic and genotypic level (Table-2 & 3).

In general, magnitude of genotype correlation tended to be higher than the phenotypic correlation. This suggested a strong genetic association between the traits and the phenotypic expression was suppressed due to environmental influence. Correlation studies indicated that emergence of plumule, germination percentage, shoot length at 20th days, fresh shoot weight, dry root weight at 20th days, dry shoot weight at 20th days and seedling vigour index I have strong positive correlation with seedlings vigour index II at genotypic level indicating relative utility of these traits for selection. These findings are in agreement with Hadi *et al.*, (2010) [8] for germination, seed viability, and seed vigour. In the present study three genotypes namely AMS 20-19, AMS 100-39, and NRC 136 were found to be promising on performance basis for several traits.

Table 1: Estimates of mean, Range, variance, coefficient of variation, heritability, genetic advance, and genetic advance as % of mean

Characters	Mean ± S.Em	Range	Coefficient of variation		Heritability (%)	Genetic advance as % of mean
			Genotypic GCV (%)	Phenotypic PCV (%)		
Emergence of radicle	5.82± 0.87	3.33-9.66	31.41**.41**	40.82	59.2**2**	49.65
Emergence of plumule	5.13± 0.47	2.66-8.33	33.55	37.15	81.5	61.79
Germination %	51.33± 4.72	26.66-83.33	33.55	37.14	81.5	61.99
Root length at 20th days	4.20± 0.28	2.0-5.23	24.25	26.86	81.4	44.28
Shoot length at 20th days	28.09± 1.71	19.43-35.36	17.55	20.47	73.4	30.75
Fresh root weight at 20th days	0.08± 0.02	0.06-0.1	33.51	52.10	41.3	37.5
Fresh shoot weight at 20th days	0.74± 0.06	0.31-1.18	29.46	32.94	79.9	52.70
Dry root weight 20th days	0.01± 0.006	0.01-0.03	29.02	67.95	18.2	37.00
Dry shoot weight at 20th days	0.07± 0.006	0.05-0.11	21.77	25.54	72.6	28.57
Seed weight	10.25± 0.25	8.91-13.11	15.94	16.50	93.3	31.51
Seedling vigour index I	17.11± 1.80	8.62-33.14	48.80	52.12	87.6	93.39
Seedling vigour index II	51.46± 8.77	26.66-106.33	48.37	56.68	72.8	84.06

Table 2: Estimates of genotypic (r_g) correlation coefficient among twelve characters in soybean

Characters	Emergence of plumule	Germination %	Root length at 20th days	Shoot length at 20th days	Fresh root weight at 20th days	Fresh shoot weight at 20th days	Dry root weight at 20th days	Dry shoot weight at 20th days	Seed weight	Seedling vigour Index I	Seedling vigour index II
Emergence of radicle	0.791**	0.790**	0.305	0.878**	0.167	0.674*	0.623	0.695*	0.001	0.107	0.108
Emergence of plumule		0.552	-0.032	0.713*	0.018	0.488	0.431	0.320	-0.145	0.960**	0.885**
Germination %			-0.032	0.713*	0.018	0.488	0.431	0.320	-0.145	0.960**	0.885**
Root length at 20th days				0.731*	0.219	0.658*	0.500	0.679*	0.521	0.250	0.245
Shoot length at 20th days					0.492	0.931**	0.897**	0.756*	0.378	0.880**	0.889**
Fresh root weight at 20th days						0.753*	0.101	0.477	0.803**	0.152	0.364
Fresh shoot weight at 20th days							0.944**	0.729*	0.673*	0.678*	0.763*
Dry root weight at 20th days								0.796**	0.955**	0.590	0.693*
Dry shoot weight at 20th days									0.762*	0.533	0.731*
Seed weight										0.035	0.376
Seedling vigour Index I											0.951**

,* = significant at 5 percent and 1 percent level of significance respectively

Table 3: Estimates of phenotypic (r_p) correlation coefficient among twelve characters in soybean

Characters	Emergence of plumule	Germination %	Root length at 20th days	Shoot length at 20th days	Fresh root weight at 20th days	Fresh shoot weight at 20th days	Dry root weight at 20th days	Dry shoot weight at 20th days	Seed weight	Seedling vigour Index I	Seedling vigour index II
Emergence of radicle	0.781**	0.779**	0.158	0.670*	-0.008	0.449	0.111	0.364	-0.003	0.833**	0.681*
Emergence of plumule		0.449	0.001	0.557	0.043	0.351	0.100	0.165	-0.151	0.940**	0.736*
Germination %				0.557	0.043	0.351	0.107	0.165	-0.151	0.940**	0.736*
Root length at 20th days				0.495	0.200	0.627	0.153	0.628	0.459	0.220	0.284
Shoot length at 20th days					0.370	0.770**	0.383	0.565	0.329	0.789**	0.689*
Fresh root weight at 20th days						0.603	0.789**	0.420	0.525	0.186	0.520
Fresh shoot weight at 20th days							0.510	0.770**	0.585	0.566	0.739*
Dry root weight at 20th days								0.453	0.416	0.236	0.594*
Dry shoot weight at 20th days									0.629	0.387	0.695*
Seed weight										0.022	0.318
Seedling vigour Index I											0.827**

*, ** = significant at 5 percent and 1 percent level of significance respectively

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