

## ASSESMENT OF CORRELATION AND PATH ANALYSES FOR YIELD AND ITS COMPONANT TRAITS IN SOYBEAN [(*Glycine max* (L.) Merrill)].

### ABSTRACT

Comment [NR1]: Key word?

A study was conducted with an aim to understand character association and cause-effect relationship in Randomized Complete Block Design accommodating 30 genotypes randomly in three replicates. These genotypes evaluated for twenty-seven traits: five phenological, nine agromorphological, eight physiological traits (from field trial) and five physiological traits (from laboratory experiment) recorded and subjected to statistical and biometrical analyses. The Positive association of flowering traits (days to tubercles formation→ days to flower budding→ days to first flowering→ days to cessation) and uncorrelated with days to physiological maturity can be precisely utilized in selecting. Late physiological maturity increases seedling dry weight, plant height, clusters and seeds per pod while reducing leaf area index, seed weight and dry matter efficiency. With an increase in the primary branches corresponding more secondary branches, cluster/plant, seed weight and effective rainfall use efficiency noticed. Effective rainfall use efficiency positively correlated with primary branches, secondary branches, clusters/plant, germination relative index, seedling length, harvest index. Towards polygenic complex trait seed yield per plant had a high positive correlation and highest positive direct effect of effective rainfall use efficiency and vigour index I considered as selection criteria.

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### Introduction

Golden bean and miracle crop are most commonly used synonymously for soybean. Although it had 40% quality protein (glycine, tryptophan and lysine) and comparatively lesser quantity of (20%) quality oil, it mainly popular as an oilseed crop rather than a pulse crop because of its extraordinary oil qualities: no cholesterol, essential heart friendly omega-3 fats etc. It belongs to genus *Glycine*, species *max*, family Leguminosae, sub-family papilinoideae and tribe Phaseoleae. *Glycine* is derived from the Greek word *glykus*, which means sweet (Hymowitz and Newell, 1981). The sub genus *Glycine* consists of several (about 22) wild perennial species. Both the

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species *Glycine max* and *Glycine soja* hybridize readily. *Glycine max* (diploid) and *Glycine soja* (diploid), chromosome number  $2n=40$ .

The productivity of soybean is quite low in our country as compare to top soybean producing countries of the world which indicate a considerable scope to enhance yielding potential. However, direct selection for yield alone is usually not very effective or may often be misleading. Hence, selection based on its component character could be more efficient (Kumar *et al.*, 2013; Yadav, S. and Pandey, A., 2018). To know the contribution of each component traits towards yield, association studies should be conducted. Further path analysis can reveal whether this association is direct from particular trait or indirect through any other component trait(s). So, association and path analysis study of component traits of interest can provide a wider understanding towards soybean genetic improvement.

Therefore, the present work is one such effort to study the association and cause-effect relationship among 27 different characters, as this provides wider scope for selection which is the basic requisite for every crop improvement.

### Materials and methods

The experiment was carried out during *kharif*, 2019 at the farm of the Tirhut College of Agriculture, Dholi (25.5°N, 35.4°S and 52.2m MSL) in Muzaffarpur District (North Bihar) located in an eco-geographical region I Sub region IV of Bihar. Thirty entries (including 3 checks) were sown in Randomized Complete Block Design. Each plot consisted three rows of 3meter length. The row to row and plant to plant distance was 45cm and 5cm, respectively. Trial laid out for 27 (22 field and 5 laboratory screening) morpho-physiological traits viz., germination relative index seedling length (cm), seedling dry weight (g), vigour/vigor index I, vigour/vigor index II, formation of flower tubercles (days), flower budding (days), first flowering (days), cessation of flower (days), physiological maturity (days), plant height (cm), main shoot length (cm), primary branches plant<sup>-1</sup>, secondary branches plant<sup>-1</sup>, no of clusters plant<sup>-1</sup>, no of pods cluster<sup>-1</sup>, no of pods plant<sup>-1</sup>, pod length (cm), no of seeds pod<sup>-1</sup>, growing degree days (°C), specific leaf weight (g/cm<sup>2</sup>), leaf area index, 100-seed weight (g), harvest-index (%), dry matter efficiency, effective rainfall use efficiency, seed yield plant-1 (g). Data for individual characters observed, replication-wise and mean data was used for statistical analyses.

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Comment [NR3]: In this section, write more details about the measured traits. for example With what device is the leaf area index measured?

The Correlation coefficient ~~were was~~ calculated as per Al-jibouri *et al*, 1958 and path coefficient analysis were calculated as per Dewey & Lu, 1959.

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## Result and discussion

**Correlation coefficient:** The result (Table-1) regarding genotypic, phenotypic correlation coefficient showed that, due to the influence of environment, mostly the reduced magnitude of phenotypic correlation coefficients observed; although few pairs of traits: Primary branches-Secondary branches, Primary branches-Effective rainfall use efficiency, Dry matter efficiency-Harvest index, Seed yield per plant-Primary branches, Secondary branches-Effective rainfall use efficiency, environment favored resulting in a higher magnitude of phenotypic correlation coefficients.

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Association studies revealed that, traits related to flowering namely, Days to tubercles formation, Days to flower budding, Days to first flowering, Days to cessation were phenologically in sequence and change accordingly in positive/negative- highly significant/significant association. Means, with increase or decrease corresponding increase or decrease, in flowering attributes, in the same direction is registered. Interestingly, all these flowering traits exhibited unassociated response with days to physiological maturity; as such, it can be modified, independently, without influencing flowering traits.

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Physiological maturity, which is a very important trait related to adoption of any crop variety fitting well in crop sequences, expressed positive, highly significant correlation with plant height, secondary branches per plant, cluster per plant, seed per pod, leaf area index and seed weight. This clearly indicated that ~~by~~ increased physiological maturity duration corresponding increased plant height, secondary branches per plant, cluster per plant, seed per pod, leaf area index and seed weight can be achieved. Contrastingly, dry matter efficiency *i.e.*, per day production of genotype(s) expected to reduce due to negative association.

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Taller plant height increases main stem length (Positive significant association), but significantly decreases dry matter efficiency and growing degree days.

Effective rainfall use efficiency reflected its importance towards soybean yielding ability, as it was ~~positively~~ and highly significantly associated with grain yield per plant; along with both branching attributes (primary branches per plant and secondary branches per plant), clusters per plant, seedling length and ~~vigour~~vigor index-I.

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Positive, highly significant association of both branching attributes (primary branches per plant and secondary branches per plant) with grain yield per plant; along with positive, significant association of primary branches per plant with seven morpho-physiological traits like secondary branches per plant, clusters per plant, leaf area index, seed weight, effective rainfall use efficiency. This indicated the scope of increasing primary branches per plant for increasing secondary branches per plant, clusters per plant, leaf area index, seed weight and effective rainfall use efficiency; whereas secondary branches per plant had Positive, highly significant association with clusters per plant and effective rainfall use efficiency, thus reflected the importance of both branching traits towards grain yield per plant.

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Clusters per plant, ~~vigour~~vigor index-I and Seedling length had highly significant positive correlation with grain yield per plant also exhibited similar association with pods per plant, effective rainfall use efficiency (with clusters per plant); ~~with~~-germination, seedling length and effective rainfall use efficiency (with ~~vigour~~vigor index-I); effective rainfall use efficiency and vigour index-I with seedling length.

The Rest of the character pairs indicated weak inter-relationship or un-correlated response with grain yield per plant or between other traits like flowering traits with days to physiological maturity.

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Effective rainfall use efficiency, ~~vigour~~vigor index-I, seedling length, primary and secondary branches and clusters per plant indicated their importance and desirability towards main goal, the yielding ability; as the genotypes with more seedling length, high effective rainfall use efficiency, more primary and secondary branches and clusters per plant may contribute towards high yielding soybean cultivar development.

Comment [NR4]: Valid reference?

In accordance with the above findings in soybean, Significant positive correlation with seed yield per plant have also been reported by Aditya *et al.* 2011 and Patil *et al.*, 2011 (with primary branches per plant); by Koraddi *et al.*,2015 and Mili *et al.*,\_2017 (with number of

branches per plant); by Aditya *et al.* 2011, Koraddi *et al.* ,2015; and Mili *et al.*,\_2017 (with number of pods per plant).

**Path coefficient:** Phenotypic path coefficient analysis (Table-2) of different morpho-physiological and yield traits on seed yield per plant revealed that effective rainfall use efficiency a had highest positive direct effect followed by vigour index-I and dry matter efficiency which reflected high to moderate positive direct effect towards grain yield per plant. Effective rainfall use efficiency, besides its very high direct effect and highly significant positive correlation ~~with~~ grain yield per plant; had also helped primary branches per plant, seeds per pod and clusters per plant in building –up their positive, significant association with grain yield per plant.

The Hhigh negative direct effect of seedling length, vigour index –II and harvest index towards grain yield per plant had been noticed. Although seedling length expressed significant positive correlation with grain yield per plant, but its highest negative direct effect towards grain yield per plant makes this trait ineffective for yield improvement. The vVery low residual effect might be due to the effective selection of phenol-morpho-physiological traits studied in present research study, which expressed very low percentage of unknown-unstudied factors.

Several soybean researchers (Aditya *et al.*, 2011; Patil *et al.*, 2011; Koraddi *et al.*, 2015; Ghiday, T., Amogne, A., Tefera, G., & Malede, M. 2017) reported importance of morpho-physiological traits in soybean in terms of correlation and path studies.

Overall Effective rainfall use efficiency and vigour index-I found most effective traits for soybean genetic improvement.

### Conclusion:

Present study offers scope for utilizing association (direct or indirect) among-between 27 characters studied to perform effective selection in 30 soybean genotypes, including three checks, ~~for-in~~ 27 pheno-morpho-physiological traits for genetic enhancement of soybean. Flowering traits (*i.e.*, Days to tubercles-flower budding-first flower –cessation of flowering) and branching traits (primary and secondary branching) are sequential traits, positive, significantly

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correlated: means character in early phonological stage affect the characters in later phonological stages, in the same direction. Effective rainfall use efficiency, primary branches, secondary branches, seeding length and clusters per plant were important traits, positively associated with grain yield per plant and also with few other traits of interest. Two physiological traits; Effective rainfall use efficiency (highest positive direct effect) and vigour index-I (positive, moderate direct effect), were most effective yield components and revealed **the importance** of physiological traits for soybean improvement.

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**Table-1: Phenotypic and genotypic correlation coefficient for yield and 27 morpho-physiological characters in soybean [Glycine max (L.) Merrill]**

	DT	DFB	DFP	DC	DPM	PH	MSL	PB	SB	C/P	P/C	P/P	PL	S/P	GDD	SLW	LAI	SW	HI	DME	ERUE	GER	SL	SDW	V1	V2	GYPP	
DT	P	1	0.4656**	0.4254*	0.5567**	0.0896	-0.0453	0.2662	-0.1867	0.0161	-0.0086	-0.0211	-0.2403	-0.1075	-0.1335	-0.0738	-0.06	-0.2068	-0.3592	0.1068	0.0265	-0.1112	-0.1289	-0.1015	-0.2888	-0.161	-0.2868	-0.234
	G		0.6097	0.517	0.6291	0.0785	-0.0405	0.3005	-0.2235	0.1032	-0.0291	-0.103	-0.3266	-0.0644	-0.1983	-0.0642	-0.0536	-0.3278	-0.4044	0.1845	0.0822	-0.1137	-0.112	-0.1383	-0.3415	-0.2014	-0.335	-0.281
DFB	P		1	0.7501**	0.6684**	0.2618	0.3282	0.5371**	0.1069	0.1469	0.4250*	-0.1787	0.1701	-0.3075	-0.2350	-0.2625	0.0371	-0.0257	-0.2067	-0.0403	-0.1934	0.1209	-0.0972	0.1237	-0.0365	0.0666	-0.0567	0.056
	G			0.8319	0.7283	0.2893	0.3885	0.6083	0.2112	0.2584	0.5022	-0.2004	0.2373	-0.3886	-0.3114	-0.2858	0.0268	0.016	-0.2217	-0.0394	-0.2162	0.1873	-0.1486	0.1213	-0.0485	0.0267	-0.0766	0.101
DFP	P			1	0.6630**	0.1395	0.2170	0.5504**	0.0463	-0.1272	0.3037	-0.2610	0.0062	-0.2936	-0.2697	-0.1387	0.1945	-0.1084	-0.2256	0.0112	-0.0916	0.0967	-0.1395	0.1392	0.0104	0.0752	-0.0407	0.031
	G				0.7518	0.1443	0.2053	0.5889	0.0837	-0.1702	0.3721	-0.2727	0.1268	-0.332	-0.3331	-0.1402	0.2102	-0.1724	-0.2408	-0.0221	-0.1206	0.1443	-0.1815	0.1922	0.011	0.0883	-0.0454	0.055
DC	P				1	-0.0247	0.0558	0.2874	-0.0075	-0.0983	0.1855	-0.0441	0.1102	-0.3693*	-0.3085	0.0242	0.2037	-0.1847	-0.2320	0.0693	0.0617	0.064	-0.0757	-0.0176	0.0218	-0.0503	-0.0097	-0.007
	G					-0.0292	0.0552	0.32	-0.0244	-0.1532	0.2152	-0.0758	0.09	-0.3963	-0.3296	0.0294	0.2301	-0.2458	-0.2367	0.0973	0.0811	0.0525	-0.0835	-0.0095	0.0289	-0.0558	-0.005	-0.038
DPM	P					1	0.4003*	0.139	0.2806	0.3998*	0.5510**	-0.1639	0.2527	-0.2138	0.3668*	-0.9978**	0.0494	0.4301*	0.4866**	-0.061	-0.6737**	0.3112	0.1829	0.3138	-0.1287	0.3154	-0.0679	0.293
	G						0.4625	0.161	0.4605	0.5767	0.6655	-0.2125	0.3312	-0.2253	0.4152	-0.9983	0.0499	0.55	0.5039	-0.0758	-0.7063	0.4288	0.213	0.483	-0.1332	0.4664	-0.0695	0.398
PH	P						1	0.6679**	-0.1197	0.018	0.194	-0.2618	0.1643	0.0471	0.019	-0.4179*	0.1139	-0.0149	0.0431	-0.2746	-0.4647**	0.2380	-0.0475	0.3385	0.1895	0.2743	0.1941	0.229
	G							0.7823	-0.128	0.1376	0.2999	-0.3334	0.2202	0.0755	0.0256	-0.4799	0.1339	-0.0226	0.056	-0.3862	-0.5751	0.3793	-0.0476	0.6557	0.2339	0.5182	0.2465	0.355
MSL	P							1	-0.1569	-0.0898	0.1313	-0.3287	-0.0302	-0.0445	-0.1968	-0.1519	0.0729	-0.2512	-0.3661*	-0.1017	-0.177	0.1171	-0.0309	0.2471	0.1666	0.2063	0.153	0.075
	G								-0.2635	-0.1406	0.1854	-0.3934	0.02	-0.0238	-0.2832	-0.172	0.0912	-0.3025	-0.4006	-0.1223	-0.2044	0.1645	-0.0348	0.3887	0.1786	0.3146	0.165	0.105
PB	P								1	0.5700**	0.4511*	0.1827	0.2925	-0.3319	0.0693	-0.2662	-0.0406	0.5089**	0.4203*	0.2326	0.0096	0.5432**	0.1942	0.1522	0.1402	0.2024	0.1466	0.554**
	G									0.4968	0.6939	0.1657	0.5397	-0.6225	0.1636	-0.4457	-0.1049	0.9668	0.6181	0.2861	-0.0758	0.4471	0.3657	0.2729	0.229	0.3975	0.2552	0.476
SB	P									1	0.3673*	0.1152	0.2806	-0.1256	0.1534	-0.3862*	-0.2288	0.3203	0.2631	0.151	-0.131	0.4503*	0.0223	0.1292	-0.0986	0.1116	-0.0763	0.436*
	G										0.4724	0.0954	0.4332	-0.2504	0.2932	-0.5613	-0.3482	0.554	0.3418	0.0741	-0.3051	0.2295	0.1169	0.2633	-0.1075	0.2597	-0.0581	0.221
C/P	P										1	-0.0661	0.5234**	-0.2530	0.1099	-0.5496**	-0.1594	0.3290	0.2314	0.0793	-0.2950	0.4930**	0.1548	0.2473	-0.1344	0.2697	-0.1118	0.496**
	G											-0.128	0.7752	-0.3682	0.1262	-0.6646	-0.1914	0.5814	0.2636	0.0855	-0.374	0.5896	0.1604	0.439	-0.1847	0.435	-0.1627	0.598
P/C	P											1	0.3112	-0.0779	-0.0038	0.1743	-0.1482	0.0013	0.0313	0.3898*	0.4031*	0.1853	-0.1748	-0.1129	0.0967	-0.1568	0.0442	0.163
	G												0.325	-0.1013	0.05	0.219	-0.1841	0.0369	0.0377	0.5702	0.5484	0.2007	-0.1681	-0.1969	0.117	-0.222	0.0663	0.167
P/P	P												1	-0.1215	0.0964	-0.2527	-0.1225	0.3697*	0.1739	0.1443	-0.0574	0.3381	0.0655	0.2118	-0.003	0.2113	0.0082	0.356
	G													-0.2445	0.1627	-0.34	-0.1587	0.4373	0.2464	0.2859	-0.0217	0.5737	0.0658	0.4103	0.0244	0.3812	0.038	0.591
PL	P													1	0.3802*	0.203	0.0938	-0.2135	-0.1383	0.0416	0.1544	-0.1093	-0.2973	-0.0789	-0.3060	-0.1657	-0.3117	-0.010
	G														0.4667	0.2131	0.0839	-0.3021	-0.1527	0.0108	0.1406	-0.2166	-0.3462	-0.1565	-0.3598	-0.2712	-0.3659	-0.199
S/P	P														1	-0.3702*	0.1934	0.2755	0.3354	-0.041	-0.2625	-0.0142	0.0195	0.0807	-0.3135	0.0636	-0.2683	0.010
	G															-0.4192	0.2542	0.3602	0.3646	0.0156	-0.2681	0.0464	0.0424	0.2185	-0.3837	0.1824	-0.3275	0.079

		DT	DFB	DFE	DC	DPM	PH	MSL	PB	SB	C/P	P/C	P/P	PL	S/P	GDD	SLW	LAI	SW	HI	DME	ERUE	GER	SL	SDW	V1	V2	GYPP
GDD	P															1	-0.0386	-0.4298*	-0.4894**	0.0745	0.6841**	-0.3200	-0.1873	-0.3267	0.1279	-0.3286	0.0673	-0.304
	G																-0.0301	-0.5515	-0.5063	0.0904	0.7173	-0.4424	-0.2204	-0.505	0.1302	-0.489	0.0659	-0.414
SLW	P																1	-0.1981	0.1123	0.0597	0.0118	-0.1005	-0.112	-0.0161	0.0884	-0.0623	0.0704	-0.089
	G																	-0.2649	0.1289	0.0622	0.0118	-0.1652	-0.1584	-0.0211	0.1221	-0.0973	0.0955	-0.152
LAI	P																	1	0.5347**	-0.0587	-0.3042	0.1865	0.1805	0.1309	0.0474	0.1714	0.0782	0.219
	G																		0.6867	-0.0283	-0.3667	0.355	0.3588	0.3538	0.062	0.4511	0.1264	0.401
SW	P																	1	-0.0575	-0.3423	0.2523	0.2053	0.2871	0.099	0.3198	0.1328	0.297	
	G																			-0.0685	-0.3695	0.2968	0.2342	0.3982	0.1064	0.4322	0.1439	0.35
HI	P																			1	0.7739**	0.2739	0.1675	-0.1419	0.1407	-0.0653	0.1435	0.232
	G																				0.7585	0.2794	0.1907	-0.247	0.1569	-0.1227	0.1583	0.226
DME	P																				1	-0.0054	0.0104	-0.2985	0.201	-0.2433	0.1653	-0.024
	G																					-0.0927	-0.0035	-0.5087	0.2126	-0.4071	0.1721	-0.110
ERUE	P																					1	0.1962	0.4420*	0.1107	0.4506*	0.1351	0.985**
	G																						0.2892	0.8435	0.1517	0.8285	0.1915	0.979
GER	P																						1	0.2118	0.1827	0.5168**	0.3468	0.230
	G																							0.2021	0.1818	0.5724	0.3299	0.331
SL	P																							1	0.0592	0.9433**	0.1197	0.451*
	G																								0.0338	0.9163	0.0832	0.849
SDW	P																								1	0.1308	0.9798**	0.116
	G																									0.1282	0.9836	0.159
V1	P																									1	0.2347	0.474**
	G																										0.225	0.858
V2	P																										1	0.1434
	G																											0.2018
GYPP	P																											1
	G																											

\*\* & \* Sign for 1% & 5%, respectively 1%= 0.463, & 5%=0.361

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Note : DT=Days to tubercle formation-, DFB=Days to flower budding, DFF = Days to First flowering, DC=Days to cessation-, DPM = Days to Physiological maturity, PH = Plant height (cm), MSL = Main shoot length (cm), PB = Number of primary branches per plant, SB = Number of secondary branches per plant , C/P = Number of cluster per plant, P/C = Number of pods per

cluster, P/P = Number of pods per plant-, PL= Pod length (cm), S/P=Seed per pod-, GDD=Growing degree days, SLW=Specific leaf weight-, LAI=Leaf area index, SW = 100 -seed weight (g), HI = Harvest- index (%), GY = Grain yield per plant(g), DME=Dry matter efficiency, ERUE=Effective rainfall use efficiency, GER=Germination relative index, SL=Seedling length-, SDW=Seedling dry weight-, VI=~~Vigour~~Vigor index I, VII=Vigour index II

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UNDER PEER REVIEW

**Table-2: Phenotypic path coefficient analysis between pairs of 27 morpho-physiological characters in soybean [*Glycine max* (L.) Merrill]**

	DT	DFB	DFF	DC	DPM	PH	MSL	PB	SB	C/P	P/C	P/P	PL	S/P	GDD	SLW	LAI	SW	HI	DME	ERUE	GER	SL	SDW	V1	V2
DT	-0.1037	-0.0483	-0.0441	-0.0577	-0.0093	0.0047	-0.0276	0.0194	-0.0017	0.0009	0.0022	0.0249	0.0112	0.0138	0.0077	0.0062	0.0214	0.0373	-0.0111	-0.0028	0.0115	0.0134	0.0105	0.0300	0.0167	0.0297
DFB	-0.0016	-0.0035	-0.0026	-0.0023	-0.0009	-0.0012	-0.0019	-0.0004	-0.0005	-0.0015	0.0006	-0.0006	0.0011	0.0008	0.0009	-0.0001	0.0001	0.0007	0.0001	0.0007	-0.0004	0.0003	-0.0004	0.0001	-0.0002	0.0002
DFF	-0.0179	-0.0315	-0.0420	-0.0279	-0.0059	-0.0091	-0.0231	-0.0019	0.0053	-0.0128	0.0110	-0.0003	0.0123	0.0113	0.0058	-0.0082	0.0046	0.0095	-0.0005	0.0038	-0.0041	0.0059	-0.0058	-0.0004	-0.0032	0.0017
DC	0.0018	0.0022	0.0022	0.0033	-0.0001	0.0002	0.0009	0.0000	-0.0003	0.0006	-0.0001	0.0004	-0.0012	-0.0010	0.0001	0.0007	-0.0006	-0.0008	0.0002	0.0002	0.0002	-0.0002	-0.0001	0.0001	-0.0002	0.0000
DPM	-0.0055	-0.0160	-0.0085	0.0015	-0.0613	-0.0245	-0.0085	-0.0172	-0.0245	-0.0338	0.0100	-0.0155	0.0131	-0.0225	0.0612	-0.0030	-0.0264	-0.0298	0.0037	0.0413	-0.0191	-0.0112	-0.0192	0.0079	-0.0193	0.0042
PH	0.0001	-0.0007	-0.0004	-0.0001	-0.0008	-0.0020	-0.0013	0.0002	0.0000	-0.0004	0.0005	-0.0003	-0.0001	0.0000	0.0008	-0.0002	0.0000	-0.0001	0.0005	0.0009	-0.0005	0.0001	-0.0007	-0.0004	-0.0005	-0.0004
MSL	0.0041	0.0083	0.0085	0.0044	0.0021	0.0103	0.0154	-0.0024	-0.0014	0.0020	-0.0051	-0.0005	-0.0007	-0.0030	-0.0023	0.0011	-0.0039	-0.0056	-0.0016	-0.0027	0.0018	-0.0005	0.0038	0.0026	0.0032	0.0024
PB	0.0035	-0.0020	-0.0009	0.0001	-0.0052	0.0022	0.0029	-0.0185	-0.0106	-0.0084	-0.0034	-0.0054	0.0062	-0.0013	0.0049	0.0008	-0.0094	-0.0078	-0.0043	-0.0002	-0.0101	-0.0036	-0.0028	-0.0026	-0.0038	-0.0027
SB	0.0002	0.0014	-0.0012	-0.0009	0.0038	0.0002	-0.0008	0.0054	0.0095	0.0035	0.0011	0.0027	-0.0012	0.0014	-0.0036	-0.0022	0.0030	0.0025	0.0014	-0.0012	0.0043	0.0002	0.0012	-0.0009	0.0011	-0.0007
C/P	-0.0003	0.0149	0.0106	0.0065	0.0193	0.0068	0.0046	0.0158	0.0129	0.0350	-0.0023	0.0183	-0.0089	0.0038	-0.0192	-0.0056	0.0115	0.0081	0.0028	-0.0103	0.0173	0.0054	0.0087	-0.0047	0.0094	-0.0039
P/C	0.0001	0.0008	0.0012	0.0002	0.0008	0.0012	0.0015	-0.0009	-0.0005	0.0003	-0.0047	-0.0015	0.0004	0.0000	-0.0008	0.0007	0.0000	-0.0001	-0.0018	-0.0019	-0.0009	0.0008	0.0005	-0.0005	0.0007	-0.0002
P/P	0.0032	-0.0022	-0.0001	-0.0015	-0.0033	-0.0022	0.0004	-0.0039	-0.0037	-0.0069	-0.0041	-0.0132	0.0016	-0.0013	0.0033	0.0016	-0.0049	-0.0023	-0.0019	0.0008	-0.0045	-0.0009	-0.0028	0.0000	-0.0028	-0.0001
PL	0.0016	0.0046	0.0044	0.0055	0.0032	-0.0007	0.0007	0.0049	0.0019	0.0038	0.0012	0.0018	-0.0148	-0.0056	-0.0030	-0.0014	0.0032	0.0021	-0.0006	-0.0023	0.0016	0.0044	0.0012	0.0045	0.0025	0.0046
S/P	0.0007	0.0012	0.0013	0.0015	-0.0018	-0.0001	0.0010	-0.0003	-0.0008	-0.0005	0.0000	-0.0005	-0.0019	-0.0050	0.0019	-0.0010	-0.0014	-0.0017	0.0002	0.0013	0.0001	-0.0001	-0.0004	0.0016	-0.0003	0.0013
GDD	0.0117	0.0416	0.0220	-0.0038	0.1579	0.0661	0.0240	0.0421	0.0611	0.0870	-0.0276	0.0400	-0.0321	0.0586	-0.1583	0.0061	0.0680	0.0775	-0.0118	-0.1083	0.0506	0.0296	0.0517	-0.0202	0.0520	-0.0106
SLW	-0.0023	0.0014	0.0074	0.0078	0.0019	0.0043	0.0028	-0.0015	-0.0087	-0.0061	-0.0057	-0.0047	0.0036	0.0074	-0.0015	0.0382	-0.0076	0.0043	0.0023	0.0005	-0.0038	-0.0043	-0.0006	0.0034	-0.0024	0.0027
LAI	-0.0060	-0.0007	-0.0031	-0.0053	0.0124	-0.0004	-0.0072	0.0147	0.0092	0.0095	0.0000	0.0107	-0.0062	0.0079	-0.0124	-0.0057	0.0289	0.0154	-0.0017	-0.0088	0.0054	0.0052	0.0038	0.0014	0.0049	0.0023
SW	0.0009	0.0005	0.0005	0.0006	-0.0012	-0.0001	0.0009	-0.0010	-0.0006	-0.0006	-0.0001	-0.0004	0.0003	-0.0008	0.0012	-0.0003	-0.0013	-0.0024	0.0001	0.0008	-0.0006	-0.0005	-0.0007	-0.0002	-0.0008	-0.0003
HI	-0.0182	0.0069	-0.0019	-0.0118	0.0104	0.0468	0.0173	-0.0396	-0.0257	-0.0135	-0.0664	-0.0246	-0.0071	0.0070	-0.0127	-0.0102	0.0100	0.0098	-0.1704	-0.1319	-0.0467	-0.0285	0.0242	-0.0240	0.0111	-0.0245
DME	0.0054	-0.0392	-0.0185	0.0125	-0.1364	-0.0941	-0.0358	0.0019	-0.0265	-0.0597	0.0816	-0.0116	0.0313	-0.0531	0.1385	0.0024	-0.0616	-0.0693	0.1567	0.2024	-0.0011	0.0021	-0.0604	0.0407	-0.0493	0.0335
ERUE	-0.1089	0.1184	0.0947	0.0627	0.3047	0.2331	0.1146	0.5319	0.4410	0.4828	0.1814	0.3311	-0.1070	-0.0139	-0.3134	-0.0984	0.1826	0.2471	0.2682	-0.0053	0.9793	0.1921	0.4329	0.1084	0.4412	0.1323
GER	0.0052	0.0039	0.0056	0.0030	-0.0073	0.0019	0.0012	-0.0078	-0.0009	-0.0062	0.0070	-0.0026	0.0119	-0.0008	0.0075	0.0045	-0.0072	-0.0082	-0.0067	-0.0004	-0.0079	-0.0401	-0.0085	-0.0073	-0.0207	-0.0139
SL	0.0256	-0.0312	-0.0351	0.0044	-0.0791	-0.0853	-0.0623	-0.0384	-0.0326	-0.0623	0.0285	-0.0534	0.0199	-0.0203	0.0823	0.0040	-0.0330	-0.0724	0.0358	0.0752	-0.1114	-0.0534	-0.2520	-0.0149	-0.2378	-0.0302
SDW	-0.0392	-0.0050	0.0014	0.0030	-0.0174	0.0257	0.0226	0.0190	-0.0134	-0.0182	0.0131	-0.0004	-0.0415	-0.0425	0.0173	0.0120	0.0064	0.0134	0.0191	0.0272	0.0150	0.0248	0.0080	0.1356	0.0177	0.1328
V1	-0.0482	0.0199	0.0225	-0.0150	0.0944	0.0821	0.0617	0.0605	0.0334	0.0807	-0.0469	0.0632	-0.0496	0.0190	-0.0983	-0.0186	0.0513	0.0957	-0.0195	-0.0728	0.1348	0.1546	0.2822	0.0391	0.2992	0.0702
V2	0.0536	0.0106	0.0076	0.0018	0.0127	-0.0363	-0.0286	-0.0274	0.0143	0.0209	-0.0083	-0.0015	0.0582	0.0501	-0.0126	-0.0132	-0.0146	-0.0248	-0.0268	-0.0309	-0.0252	-0.0648	-0.0224	-0.1831	-0.0439	-0.1869
GYP	-0.2343	0.0562	0.0314	-0.0076	0.2935	0.2297	0.0754	0.5547	0.4361	0.4960	0.1636	0.3561	-0.1012	0.0102	-0.3047	-0.0897	0.2192	0.2979	0.2325	-0.0246	0.9857	0.2309	0.4518	0.1160	0.4747	0.1434

R SQUARE=0.9916 RESIDUAL EFFECT = 0.092

Note : DT=Days to tubercle formation-, DFB=Days to flower budding, DFF = Days to First flowering, DC=Days to cessation-, DPM = Days to Physiological maturity, PH = Plant height (cm), MSL = Main shoot length (cm), PB = Number of primary branches per plant, SB = Number of secondary branches per plant-, C/P = Number of cluster per plant, P/C = Number of pods per cluster, P/P = Number of pods per plant-, PL= Pod length (cm), S/P=Seed per pod-, GDD=Growing degree days, SLW=Specific leaf weight-, LAI=Leaf area index, SW = 100 -seed weight (g), HI = Harvest- index (%), GY = Grain yield per plant(g), DME=Dry matter efficiency, ERUE=Effective rainfall use efficiency, GER=Germination relative index, SL=Seedling length-, SDW=Seedling dry weight-, VI=Vigour index I, VII=Vigour index I

## REFERENCES

- Hymowitz, T., and Newell, C. A. (1981). Taxonomy of the genus *Glycine*, domestication and uses of soybeans. *Economic botany*, 35(3), 272-288.
- Kumar, A., Lal G. M. and Mishra P. K. (2013). Genetic Variability and character association for yield and it's components in soybean. *Annals of Plant and Soil Research*, 16(1): 48-52.
- Yadav, S. and Pandey, A. (2018). Inter relationship and path analysis for seed yield in Indian mustard [*Brassica juncea* (L.) Czern and Coss]. *International Journal of chemical studies*, 6(5):1716-1731.
- Al- Jibouri, H., Miller, P. A., and Robinson, H. F. (1958). Genotypic and environmental variances and covariances in an upland Cotton cross of interspecific origin 1. *Agronomy journal*, 50(10): 633-636.
- Dewey, J. R. and Lu, K. H. (1959). A correlation and path co-efficient analysis of components of crested wheat seed production. *Agronomy Journal*, 51(9): 515-8.
- Aditya, J. P., Bhartiya, P., and Bhartiya, A. (2011). Genetic variability, heritability and character association for yield and component characters in soybean (*G. max* (L.) Merrill). *Journal of Central European Agriculture*, 12(1): 27-34.
- Patil, S. S., Naik, M. R., Patil, P. P. and Shinde, D.A. (2011). Genetic variability, correlation and path analysis in soybean. *Navsari Agricultural University Journal*, 34(1): 36-40.
- Koraddi, S., Basavaraja, G., and Vijayakumar, S. I. A. (2015). Correlation and path coefficient analysis for yield and its components in soybean (*Glycine max* l. merrill). *The bioscan*, 10(4):2065-2067.
- Mili, K. N., Shirazy, B. J., and Mahbub, M. M. (2017). Evaluation of Genetic Diversity in Soybean (*Glycine max* (L.) Merrill) Genotypes Based on Agronomic Traits. *Scientia*, 20(3): 92-98.
- Ghiday, T., Amogne, A., Tefera, G., and Malede, M. (2017). Heritability, Genetic advance and path coefficient analysis for grain yield and its component characters in soybean (*Glycine max* L. Merrill). *International Journal of Research Studies in Agricultural Sciences*, 3(5): 1-11.

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