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Correlation and Path Coefficient Analysis for Seed Yield and Yield Related Traits in Soybean (*Glycine max* (L.)) Genotypes

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Abstract: Soybean is a very interesting food crops and several production constraints are accountable for the low productivity including poor soils fertility, lack of early maturing or drought tolerant variety, lack of high yielding varieties, disease and pest. Therefore experiment was conducted to assess the extent of genetic variability and traits associations in soybean genotypes for grain yield and its related components and thereby generate information as well as identify superior genotypes for further improvement program. A total of thirty six soybean genotypes were tested using simple lattice design with two replications at Fedis during 2018 cropping season. Most of the traits showed positive correlations among themselves both at phenotypic and genotypic levels. Seed yield had highly significant and positive genotypic and phenotypic correlation with primary number of branches/plant, number of pods/plant, number of seeds/pod and plant height, indicating that simultaneous improvement of grain yields with the associated traits is favorable. Plant height exerted the highest genotypic (0.74) and phenotypic (0.54) direct effect on seed yield, and followed by hundred seeds weight and number of pods/plant showed higher genotypic direct effect on seed yield. This suggested that attention should be given for these traits mainly for direct and indirect selection for variety development.

Keywords: Correlation, Path Coefficient, Genotypes

1. Introduction

Soybean (*Glycine max* (L.) is a very interesting food crops used as feed, food, raw material for producing high-quality protein and oil worldwide and in Africa including Ethiopia [1]. Globally, over 100 million metric tons of soybeans are produced each year. United States, Argentina and Brazil produce a large amount of soybean. Among the African countries, South Africa is the largest soybean producer followed by Nigeria, Zambia, and Uganda. Including Ethiopia, other countries like Zimbabwe, Malawi, Ghana, and Sudan, have all experienced sizeable commercial soybean expansion [2]. Western parties of Ethiopia Oromia and Benishangul Gumuz, and to a lesser extent, in the Amhara region are the major soybean production areas. Even though the crop has very important food and feed advantages, several production constraints are accountable for the low productivity including poor soils fertility, lack of early maturing or drought tolerant variety, lack of high yielding varieties, disease and pest. The experimentation was undertaken to determine nature of association of seed yield and yield component traits of soybean genotypes. Therefore, the study was initiated with the objective to estimate associations among seed yield and yield component traits.

2. Materials and Methodologies

2.1. Experimental Site

The experimentation was undertaken at FARC, Eastern Hararghe zone. FARC, is located at the latitude of 09° 07' North and longitude of 042° 04' East. The experimental area receives a mean rainfall of about 749.9 mm.

In this field experiment, a total of 36 genotypes which is obtained from BARC were used as experimental materials. The genotypes were grown under rain fed conditions in 2018.

simple lattice designs (6*6) with two replications, four rows of 3 m length, 1.80 m width and 0.45 m row space with plot size of (5.40 m^2) were experimental design.

2.2. Collected Data

Days to flowering, Days to maturity, Hundred Seed weight, Grain yield per hectare, Plant height (cm), Number of Primary branches per plant, Number of Pods per plant and Number of Seeds per pod were collected and analyzed.

2.3. Estimation of Correlation Coefficient

The Phenotypic and genotypic correlations were estimated as suggested by [6] using the following equations.

$$_{\gamma}pxy = \frac{\sigma pxy}{\sqrt{\sigma^2 px * \sigma^2 py}},$$

Where,

σpxy =Phenotypic correlation coefficient between X and Y

$\sigma^2 px$ = Phenotypic variance of X,

$\sigma^2 py$ =Phenotypic variance of Y

$$_{\gamma}gxy = \frac{\sigma gxy}{\sqrt{\sigma^2 gx * \sigma^2 gy}}$$

$_{\gamma}gxy$ =Genotypic correlation coefficient between characters X and Y

$\sigma^2 gx$ =Genotypic variance of character X

$\sigma^2 gy$ = Genotypic variance of character Y

Correlation value (r = 1) implies perfect (100%) correlation, where both traits vary hand in hand r = -1 means there is 100 % correlation between two characters, but they vary in opposite direction, and r = 0 implies that there is no correlation at all between the two characters [3].

2.4. Estimate of Path Coefficient Analysis

Path coefficient analysis was conducted as suggested by [4, 5].

$$r_{xy} = p_{xy} + \sum r_{xk} p_{ky}$$

Hint:

rxy = Mutual association between the independent variable 'x' and the dependent variable 'y' as measured by correlation coefficient.

p_{xy} = Components of direct effects of the independent variable (x) on dependent variable (y) as measured by the path coefficients; and

$\sum r_{xk} P_{ky}$= Summation of components of indirect effects of independent trait (x) on the given dependent trait (y) via all other independent variables (k).

The contribution of the remaining unknown factor was measured as the residual factor. This was calculated as: residual effect=$\sqrt{1-R^2}$, where $R^2 = \sum p_{xy} r_{xy}$

3. Results and Discussions.

3.1. Correlation Coefficients at Genotypic and Phenotypic Levels

The result shows that the magnitude of genotypic correlation is relatively higher than phenotypic correlation which indicated presence of inherent association among various traits and strong association between these traits genetically. Similarly, [7] reported that higher genotypic correlations coefficient for most traits tested. Leite, W. et al. [8] founds that phenotypic correlation is less than genotypic correlation, indicating the genetic factors contributed more than the environmental factor to the variations among the studied materials. Contrary, [9] reported higher phenotypic correlation values than the genotypic correlation coefficient.

Table 1. *Estimates of genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients for traits of soybean genotypes.*

Characters	DF	DM	PB	SB	PPP	SPP	PH	HSW	GY
DF	1.00	0.79**	0.06	0.15	0.19	0.10	0.50**	-0.18	0.33*
DM	0.76**	1.00	-0.27*	0.04	-0.08	-0.15	0.39*	0.14	0.36*
PB	0.07	0.23	1.00	0.27*	0.69**	0.25	0.06	-0.22	0.59**
SB	0.14	0.05	0.29*	1.00	0.30*	-0.05	0.29*	-0.34*	0.35*
PPP	0.17	-0.07	0.66**	0.29*	1.00	0.51**	0.32*	-0.26*	0.72**
SPP	0.10	-0.12	0.24	-0.03	0.52**	1.00	0.26*	0.08	0.57**
PH	0.50**	0.39*	0.08	0.29*	0.33*	0.26*	1.00	-0.33*	0.43*
HSW	-0.17	0.14	-0.16	-0.30*	-0.23	0.06	-0.31*	1.00	0.27*
GY	0.32*	-0.26*	0.54**	0.32*	0.69**	0.52**	0.41**	0.25*	1.00

* Significant (P≤0.05) and ** =highly significant (P≤0.01)

Key: DF= days to flowering, DM= days to maturity, PB= primary branches/plant, SB= secondary branches/plant, PPP= pods/plant, SPP=seeds/pod, PH=plant height, HSW=hundred seeds weight and GY=grain yield.

Seed yield had highly significant and positive genotypic and phenotypic correlation coefficients with number of primary branches/plant, number of pods/plant, number of seeds/pod and plant height, indicating that it is favorable for the plant breeders for simultaneous improvement of the grain yields with the associated traits. Significant and positive genotypic & phenotypic correlation was estimated for days to flowering, secondary branches/plant and hundred seeds weight with grain yield. The results was agreed with the work of [10] that grain yield showed significant positive correlations with branches/plant, pod length, pods/plant, seeds/plant and hundred seed weight. Besides, the result revealed that those materials are better adapted to moisture stress environments where there is short rainy season.

3.2. Genotypic and Phenotypic Correlation Among Component Characters

Significant correlation coefficients were estimated among the component characters (Table 1). Plant height showed highly significant and positive genotypic correlation with days to flowering (rg=0.50); significant and positive correlation with days to maturity (rg=0.39), secondary branches/plant (rg=0.29), pods/plant (rg=0.32) and seeds/pod (rg=0.26), indicating the existence of the association between plant height and other traits. Whereas, hundred seeds weight (rg=-0.33) showed significant and negative correlation with plant height which implies increase in plant height will lead to decrease in hundred seeds weight and vice versa. The observed associations are consistent with [11, 12] in which positive and highly significant correlation of plant height were observed with pods/plant, primary branches/plant, seeds/plant, seed dry weight and seed yield.

At phenotypic level, highly significant and positive correlation was found between plant height and days to flowering. Significant and positive correlation was found among plant height and days to maturity, secondary branches/plant, pods/plant and seeds/pod. Highly significant and positive phenotypic correlation was estimated for primary branches/plant with pods/plant. Significant and positive phenotypic was also estimated for secondary branches/plant and seeds/pod show significant and positive phenotypic correlation with primary branches/plant. Similarly, secondary branches/plant shows significant and positive genotypic correlation with primary branches/plant.

Positive & highly significant genotypic correlation was estimated for pods/plant with primary branches/plant and significant genotypic correlation with secondary branches/plant. It also shows positive and highly significant phenotypic correlation with seeds/pod and positive and significant phenotypic correlation with plant height. Similarly, seed/pod shows significant and positive correlation with pods/plant and plant height both genotypic and phenotypic. The present result revealed that making selection and improvement for a particular trait could help simultaneous improvement in the associated trait(s). This suggested that traits show high variability should be used while selecting for improvement in grain yield.

3.3. Path Coefficient Analysis

3.3.1. Genotypic Direct and Indirect Effects of Various Traits on Grain Yield

Estimation of direct & indirect effects for genotypic correlation revealed that hundred seeds weight has the highest positive direct effect on seed yield (0.803) followed by plant height (0.735) and pods/plant (0.489). While, seeds/pod (0.176), primary branches/plant (0.127) and secondary branches/plant showed non-significant and positive direct effect. So, the improvement of seed yield is as the expense of hundred seeds weight, plant height, pods/plant, secondary branches/plant, primary branches/plant and seeds/pod. Similarly, [10] reported the highest positive indirect effects on yield/plant were the number of pods/plant, number of branches/plant, the number of seeds/plant, hundred seed weight, pod length and days to flowering.

Table 2. *Estimates of direct (bold diagonal) and indirect effect (off diagonal) at genotypic level of traits on grain yield.*

Traits	DF	DM	PB	SB	PPP	SPP	PH	HSW	r_g
DF	-0.045	-0.062	0.008	0.006	0.095	0.019	0.375*	-0.067	0.329*
DM	-0.004	-0.668*	-0.035	0.005	-0.041	-0.027	0.287*	0.119	-0.364*
PB	-0.003	0.186	0.127	0.032	0.340*	0.044	0.049	-0.18	0.594**
SB	-0.002	-0.031	0.035	0.115	0.295	-0.009	0.22	-0.274*	0.348*
PPP	-0.009	0.057	0.088	0.069	0.489*	0.003	0.24	-0.216	0.722**
SPP	-0.005	0.101	0.032	-0.006	0.009	0.176	0.194	0.065	0.566**
PH	-0.023	-0.261	0.008	0.034	0.16	0.046	0.735*	-0.272*	0.428**
HSW	0.004	0.099	-0.028	-0.039	-0.132	0.014	-0.249	0.803*	0.274*

Key: *=significant (P≤0.05), **= highly significant (P≤0.01), Residual effect=0.39 DF=days to flowering, DM=days to maturity, PB=primary branches/plant, PPP=pods/plant, SPP=seeds/pod, PH=plant height and HSW=hundred seeds weight, r_g =genotypic correlation with grain yield.

Days to maturity exerted the highest negative direct and indirect effect on grain yield. This implies that early maturing genotypes gave high yield than late maturing genotypes. The study area was characterized by shortage of rain fall during the experimentation and thus the main reason for low yielding ability of the late maturing genotypes. Therefore, developing early maturing genotypes may overcome the problem of shortage of rainfall for the area.

Estimation of path revealed that primary branches/plant exerted positive genotypic direct effect to seed yield and also showed positive genotypic indirect effect through pods/plant and seeds/plant to grain yield. The causes of the positive association of primary branches/plant with yield were mainly due to its positive direct effect and indirect effects through pods/plant and seeds/pod.

3.3.2. Phenotypic Path Coefficient Effects of Various Characters on Grain Yield

Phenotypic direct and indirect coefficient showed that pods/plant (0.63) exerted the highest positive direct effect on grain yield, followed by plant height (0.54). Similarly, seeds/pod, primary branches/plant and secondary branches/plant exerted direct and positive phenotypic correlation with grain yield. Plant height had positive direct effect and significant positive phenotypic correlation with grain yield. Its indirect effect via seeds/plant and other traits were positive and negligible. Therefore, the positive correlation coefficient with grain yield was due to its direct effect indicating that improving plant height and pods per plant resulted in the improvement of grain yield by default. Pods/plant exerted strong positive direct contribution on grain yield indicating direct selection may be effective in improving the grain yield through improving number of pods per plant. It had negligible indirect contribution via the rest of the traits. Similar result was reported by [7]. Days to maturity exerted negative direct effect and negative correlation to grain yield. As the number of days the plant takes to mature increases, the grain yield of genotypes decreases. This urges to focus on developing early maturing varieties in the study area. Similarly, [10] investigated days to 50% flowering (-0.995), days to maturity (-0.125) and number of seeds/pod (-0.277) had negative direct effects on grain yield per plant. Phenotypic residual effects (0.36) indicated that traits included in the study explained 64% of the phenotypic level of variation in grain yield. This further elaborates that yield attributing traits chosen in the study were good.

In general, the present study suggested that pods/plant, plant height, hundred seeds weight and primary branches/plant should be given more stress while determining selection breeding strategies for successful soybean yield improvement. Similarly, Sunday, O., and Omolara, O. [13] reported that the important yield attributes are the number of pods per plant, seeds per pod and seed weight, which determine the seed yield of soybean.

Table 3. *Estimates of direct (bold diagonal) and indirect effect (off diagonal) at phenotypic level of traits on grain yield.*

Traits	DF	DM	PB	SB	PPP	SPP	PH	HSW	r_p
DF	0.091	-0.317	0.108	0.01	0.111	0.042	0.268	0.001	0.315*
DM	0.033	-0.864**	0.045	0.004	0.172	0.027	0.317	0.002	-0.264*
PB	0.053	-0.207	0.187	0.007	0.291	0.052	0.152	0.001	0.535**
SB	0.013	-0.147	0.056	0.024	0.186	0.029	0.161	0.00	0.321*
PPP	0.016	-0.237	0.031	0.007	0.625**	0.069	0.177	0.006	0.694**
SPP	0.018	-0.112	0.046	0.003	0.204	0.21	0.143	0.004	0.516**
PH	0.045	-0.512	0.072	0.007	0.207	0.056	0.536**	0.00	0.411*
HSW	0.043	-0.121	0.012	-0.007	0.27	0.055	-0.011	0.013	0.255*

Key: *=significant (P≤0.05), **=highly significant (P≤0.01) and Residual effect=0.36, DF=days to flowering, DM=days to maturity, PB=number of branches/plant, PPP= pods/plant, SPP= seeds per pod, PH=plant height and HSW=hundred seeds weight r_p= phenotypic correlation with grain yield.

4. Conclusion

Generally, the present experimentation brought out the presence of significant genetic variability among the tested genotypes for different characters. Therefore, in order to bring an effective improvement of grain yield and yield related traits of soybean, more attention should be given for traits such as number of pods per plant, number of branches per plant and plant height, which showed positive phenotypic and genotypic correlation coefficients with considerable direct and indirect effects on grain yield.

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