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Genotypic Correlation and Path Coefficient Analysis of Soybean [*Glycine max* (L.) Merr.] for Yield and Its Components

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Abstract

Genotypic correlation and path coefficient analysis were used to determine the effect of various traits as components of grain yield in 21 soybean (*Glycine max L*) genotypes. The 21 soybean genotypes were evaluated at Gezira Research Station Farm (GRSF), Agricultural Research Corporation (ARC), Wad-Medani for two consecutive seasons 2009/10 and 2010/11. Randomized complete block design with three replicates was used for laying out the field experiments. Highly significant positive genotypic correlations were detected for grain yield with days to 50% flowering, days to maturity, plant height, number of pods/plant and fodder yield. Path analysis revealed that fodder yield, plant height and days to maturity had the highest positive direct effect on grain yield. Number of pods/plant via plant height gave the highest positive indirect effect on grain yield. These results indicate that fodder yield, plant height and days to maturity can be used as selection criteria for the improvement of soybean grain yield.

Keywords: Genotypic correlation; Direct and indirect effect; *Glycine max L.*

Introduction

Soybean (Glycine max L.) is an important legume crop that grows in tropical, sub-tropical and temperate climates. Soybean seeds contain high protein content (40%) and high quality oil (20%). The major soybean producing countries are the USA, Brazil, Argentina, China and India accounting for almost 87.7% of production worldwide [1]. Demand for soybean continues to grow because of use as a major ingredient in formulations of multitude of foods, feeds and industrial productions. These applications include a wide range of soy food, shortening to biodiesel applications for soybean oil, and feed to vegetable protein substitutes for meat and dairy products for soybean meal/protein. Soybean is also primary source of high-value secondary co-products such as lecithin, vitamins, nutraceuticals and anti-oxidant [2]. In addition soybean as leguminous crop improves soil fertility by fixing atmospheric nitrogen. In Sudan soybean is a new crop struggle for existence in both irrigated and rain-fed farming. Research on soybean in Sudan started as early as 1930. Soybean varieties were tested at the Gezira Research Farm (GRF), during period from 1973-1977 [3]. Results of field trails indicated that Sudan has a great potential for growing soybeans as irrigated and rain-fed crop [4]. Nevertheless, most of the early introduced varieties had poor agronomic performance. Currently, the ongoing soybean research program at the Agricultural Research Corporation (ARC), is focusing on developing improve soybean varieties and generation suitable production packages. These efforts were successful and lead to release of two soybean varieties Sudan I and Sudan II [5], and new two technologies were generated such as plant spacing and sowing dates [6,7]. So, markets are currently available for soybean oil and meal productions due to shortage in edible oils and increase and expansion in the poultry industry in Sudan. The major challenges for soybean production in Sudan are unavailability of soybean processing and utilization technology and lack of technical know how in home consumption. A soybean variety trial conducted by the Agricultural Research Corporation (ARC), at multi-locations has identified that in irrigated farming grain yield of over 2.5ton/ha was obtained in research trials. The knowledge of genetic variability is the most important perquisite for crop improvement program. It is equally important to evaluate different soybeans backgrounds under different agro-climatic zones for adaptation and to improve selection gain. Grain yield is a complex trait and is reportedly associated with a number of component traits. These traits are themselves inter-related. Selection for grain yield only can be effective if the desired genetic variability is present in the genetic stock. Direct selection for yield as such could be misleading because successful seed selection depends on the information on genetic variability and association of yield component traits with grain yield. Hence, correlation studies accompanied with path coefficient analysis provides accurate idea of the association of different traits with grain yield. Path analysis can provide an effective means of partitioning the genotypic correlation coefficients into direct and indirect effects and gives a clear understanding of their associations with grain yield. The acknowledge of degree and direction of this relationship between different attributes and yield is invaluable to a breeder aiming to identify key traits that can profitably be exploited to achieve the desired level of grain yield improvement. In soybean, path analysis has been used to identify traits that have significant effects on grain yield [8-11]. In this study, genotypic correlation and path coefficient analysis were used to determine the effect of various traits as components of grain yield in 21 soybean genotypes.

Material and Methods

Twenty one soybean genotypes were introduced from the Intenational Institute Tropical of Agriculture (IITA), to evaluated under irrigated condition at Gezira Research Station Farm (GRSF), Agricultural Research Corporation (ARC), Wad-Medani for two consecutive season(2009/10 and 2010/11). Randomized complete block design with three replicates was used for laying out the field experiments. Each plot was represented by four ridges; 6m long, 0.8m apart and 4cm spacing between holes. Data were collected on the following eight traits; days to 50%flowering, days to maturity, height to first pod (cm), plant height (cm), 100-seed weight (g), number of pods/plant, fodder yield (kg/ha) and grain yield (kg/ha). Genotypic correlation between theses eight traits were calculated separately for each season, according to the formula suggested by Miller et al. [12], where the path coefficient analysis was conducted as described by Dewey & Lu [13], for 2009/10 season for determining direct and indirect effects of fodder yield, 100-seed weight, plant height, days to maturity and number of pods/plant on grain yield.

Results and Disscusion

Genotypic correlation between traits

Grain yield is a complex trait and is greatly affected by environmental erratic. Moreover, it is intricated in inheritance and may involve several related traits. Hence, correlation coefficient analysis is widely used to measure the degree and direction of relationships between various traits and grain yield. In the present study, genotypic correlation coefficients between eight pairs of traits were calculated separately for each season (Table 1). Highly positive genotypic correlations (P≤0.01) were detected for grain yield with days to 50%flowering, days to maturity, plant height, number of pods/plant and fodder yield in both seasons. Similar observations were drawn by Ganesamurthy & Seshadri [10]. This indicates that grain yield increases potentially with the late flowering varieties, tall plants that bear substantially high number of pods/plant and fodder yield. These traits, besides being correlated with grain yield, were highly heritable and highly correlated with each other. Thus, if they proved to be controlled by a few number of genes, selection for their combination should not be difficult. In addition, this study showed that, the late maturing varieties gave higher yields than the early maturing ones; which might be a merit or advantage under irrigated conditions. Significant genotypic correlations were found between the following yield components; plant height, number of pods/plant and fodder yield. Such association have been attributed to pleiotropy or genetic linkage, or may be due to developmentally induced relationships between components that were only indirectly consequence of gene action [14].

Table 1: Genotypic correlation coefficient between eight pairs of traits in 21 soybean genotypes evaluated at (GRSF), for two consecutive seasons (2009/10 and 2010/11).

Traits	Days to 50% Flowering	Days to Maturity	Fodder Yield	100-Seed Weight	Plant Height	Height to First Pod	Number of Pods/Plant	Grain Yield
Days to 50% flowering	1	0.767**	0.710**	-0.011	0.178	-0.174	0.382	0.694**
Days to maturity	0.954**	1	0.633**	-0.224	-0.07	-0.117	0.175	0.619**
Fodder yield	0.667**	0.787**	1	-0.3	0.487*	0.394	0.610**	0.961**
100-seed weight	-0.323	-0.363	-0.406	1	-0.127	-0.253	-0.004	-0.442*
Plant height	0.810**	0.754**	0.704**	0.008	1	0.687**	0.874**	0.735**
Height to first pod	0.654**	0.690**	0.610**	-0.106	0.819**	1	0.598**	0.424
Number of pods/plant	0.596**	0.781**	0.580**	-0.523**	0.278	0.076	1	0.805**
Grain yield	0.558**	0.721**	0.944**	-0.338	0.712**	0.570**	0.518**	1

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The values above and below the diagonal represent the genotypic correlation coefficients in 2009/10 and 2010/11 seasons, respectively. *and ** denote to the level of significant at 5% and 1%.

The trait of fodder yield was significantly and positively correlated with grain yield in both seasons, while 100-seed weight was negative and significant in the first season and it was negative and non significant for the second season with grain yield. Thus the following conclusions are drawn from the values of correlation that were obtained: (i) selection for high fodder yield will be accompanied by reduction in 100-seed weight: (ii) selection for high grain number of pods/plant is not likely to result in heavier seed weight. Such findings are in accord with those that hade been reported by Amanullah & Hatam [15], Tefera et al. [16], Machikowa & Laosuwan [11]. However, in the two seasons, fodder yield had highly significant positive genotypic correlations with other yield components, except 100-seed weight. Positive correlation of fodder yield with plant height and number of pods/plant has been reported by Ganesamurthy & Seshadri [10]. Non siginificant negative association of fodder yield with 100-seed weight has been reported by Amanullah & Hatam [15]. Negative association may occur due to competition of two developing structures of the plant for limited resources such as nutrient and water supply [14]. Nemati et al. [17] were of the view that it will be difficult to exercise simultaneous selection for traits which show negative association among them. Also, significant negative genotypic correlation was obtained between 100-seed weight and number of pods/plant. This might be due to change in direction of/and degree of association caused by differential influence of environment on the expression of traits as well as competition among them for assimilates. Such findings are in conformity with those that had been reported by Amanullah & Hatam [15] and Ganesamurthy & Seshadri [10], but at variance with those reported by Igbal et al. [18]. On the other hand, significant positive genotypic correlation coefficient was detected between plant height and height to first pod in both seasons. This indicates that if not subjected to lodging, to genotypes with tall plants and with high height to first pod which are preferred and also suitable for mechanical harvesting. Similar results were reported by Mehmet Oz et al. [19].

Path coefficient analysis

Grain yield is a complex trait; path coefficient analysis can provide an effective means of partitioning the genotypic correlation into direct and indirect effects and gives a clear understanding of their association with grain yield. Determination of the relationships among traits and between them and grain yield helps the plant breeders to identify and select for specific traits that contribute to yield.

Table 2: Path coefficients analysis of the direct and indirect effects of five traits and their genotypic correlation coefficients with grain yield kg/ha in soybean.

Effect on Grain Yield (Kg/Ha)							
Indirect Effect Via							
Trait	Direct effect	Days to maturity	Fodder yield	100-seed weight	Plant height	Number of pods/plant	Genotypic correlation with grain yield
Days to maturity	0.313		0.269	0.043	-0.029	0.023	0.619
Fodder yield	0.425	0.198		0.057	0.2	0.08	0.961
100-seed weight	-0.192	-0.07	-0.127		-0.052	-0.001	-0.442
Plant height	0.41	-0.022	0.207	0.024		0.115	0.735
Number of pods/plant	0.131	0.055	0.26	0.001	0.358		0.805

Residual effect=0.307.

Since simple correlation coefficient alone does not provide the true contribution towards yield, path analysis was carried out (Table 2 & Figure 1). Results indicate that grain yield was positively and directly affected by fodder yield (0.425) followed by plant height (0.410) and days to maturity (0.310); all these traits had positive genotypic correlation with grain yield. The great influence of these traits reflected their importance for grain yield determinations. These findings are in accord with those of many workers [20]. While, Ramana et al. [21] and Basavaraja [22] reported that plant height had the greatest positive direct effect on grain yield, Kausar [23] and shivakumar [24] found that fodder yield had the highest positive direct effect on grain yield as it was confirmed by this study. Grain yield was negatively and directly affected by 100-seed weight (-0.191). Similar results were reported by Malik et al. [20] and Showkat & Tyagi [25]. In contrast, Raut et al. [9] reported that 100-seed weight exhibited the maximum positive direct effect on grain yield. This result can be attributed to the negative indirect effect of this trait through the fodder yield (-0.127), plant height (-0.052) and days to maturity (-0.070). Moreover, this trait gave positive indirect effect on grain yield (0.057, 0.043 and 0.024) via fodder yield, days to maturity and plant height. These positive indirect effects were reduced by the negative indirect effects, exhibited through the other traits. The hundred seed weight exhibited the

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highest negative indirect effect (-0.127) on grain yield through the fodder yield. This negative indirect effect resulted from the negative genotypic relationship between fodder yield and 100-seed weight, or may be due to inverse relationship between them. This is in disagreement with Ganesamurthy & Seshadri [10], and Kausar [23] who reported that 100-seed weight showed a positive indirect effect on grain yield through fodder yield. In this study, fodder yield, plant height and days to maturity were the only traits that had great positive direct effects on grain yield and it was positively correlated with them, so selection based on them would improve soybean grain yield. However, number of pods/plant had small positive direct effect (0.131) on grain yield, but it had considerable high positive genotypic correlation coefficient with grain yield (r=0.805). The number of pods/plant revealed high positive indirect effect (0.358) on grain yield through plant height. A similar result was reached by Archana et al. [8]. Therefore, the number of pods/plant can be used as direct or indirect selection criterion to identification for higher yield genotypes, while at the same time given more number of pods/plant to the tall plant. This suggests that selection on the basis of number of pods/plant would be more efficient. The residual effect was relatively small in magnitude (0.307), indicating that most of the traits involved in the path coefficient analysis, have great effects on grain yield. Such findings were emphasized by many investigators in different crop plants, in soybean, Rahim et al. [26], in Eleweanya et al. [27] in maize. From the above results, it can be denoted that the following traits fodder yield, plant height and days to maturity should be given prime importance as they demonstrated a significant positive correlation coefficient and highly positive direct effect compared to other traits [28].

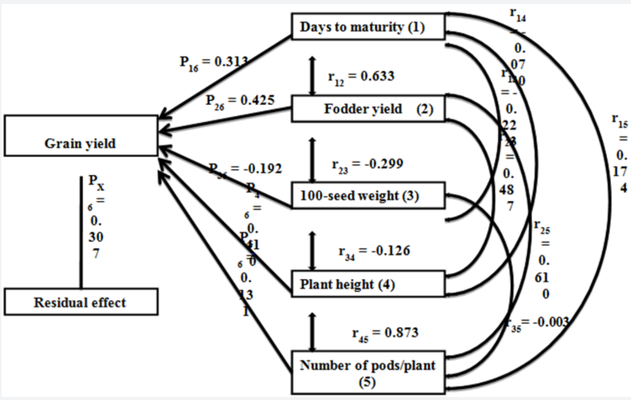

Figure 1: Diagram of the direct and indirect relationship for grain yield with five traits at the genotypic level, using path coefficient analysis.

*Single-arrowed lines indicate the path coefficients (direct effects)

** Doubled – arrowed lines indicate the genotypic correlations between traits.

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