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ASSESSMENT OF YIELD AND YIELD COMPONENTS OF SOYA-BEAN (*GLYCINE MAX* (L.) MERRIL) GROWN UNDER CONVENTIONAL AGRONOMIC PRACTICES OF LESOTHO

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ABSTRACT: *An experiment on soya-bean cultivars was conducted in Lesotho at The National University of Lesotho, Roma, with the objectives of (i) establishing the differences among the soya-bean cultivars in terms of growth and yield parameters measured (ii) to estimate the regression coefficients for yield components (iii) determining correlation among traits that influence yield of soya-bean. Field plot experiment was laid-out in a completely randomized block design with 28 treatments and three replications. Data collected were 100 grain weight, plant height, number of pods per plant, leaflets size and leaflet shape. Data were subjected to analysis of variance, multiple linear regression and person's correlation of coefficient. Results of analysis of variance revealed highly significant difference (P<0.001) among soya-bean cultivars for plant height, weight per plot and weight of 100 grains, while no significant differences were observed among leaf shape, number of pots per plant and leaf size. Regression analysis showed a highly significant (P<0.01) regression, implying that plant height contributed immensely on the yield of soya-beans followed by leaflets shape. Correlations among most parameters were high and few parameters were moderately correlated.*

Keywords: *Glycine max*, yield and yield components, correlation coefficient, Lesotho

INTRODUCTION

Soya-bean (*Glycine max*. L. Merill.) is a diploid (2x=40) leguminous crop originating from North East China plains and was distributed to Asia, Europe, United States of America and Latin America during 7th century through trade and exploration (Ningsih *et al*., 2019; Li *et al*., 2019). In China, it was not considered as a crop of economic importance and was only used as animal feed not for human consumption (Pagaro and Miransari, 2016). When it reached America in 1804, it was given a great attention to improve it and diversify its uses. The improvement was emphasized on its production and nutritional quality (Burton and Miranda, 2013). In the process of improvement, two aspects were focus on, genetic and agronomic practices. On genetic improvement programme, yield was given a high priority which is a complex trait determined by many components (Singh and Hymowity, 1999). These components of yield had varying direct and indirect effects. The association among components also existed affecting each other negatively or positively (Chavan *et al*. 2016). This association is important for the plant breeder to know as improvement of one trait may hinder the improvement effort or induce it (Ulloa *et al*., 2010). It necessitated the determination of the direction of association. Knowledge of association among the components and also with the yield is essential in the improvement of soya-bean breeding programme for effective selection (Singh and Hymowitz, 1999).

Soya-bean yield is a complex trait that is highly affected by the environmental conditions, hence selection based on yield solely excluding its components may hinder the progress in yield improvement (Drikvand, *et al.* 2011). Components of soya-bean yield are less complex in inheritance and affected by the environmental conditions to a less extent (Shahidul *et al*. 2016). For a significant yield improvement to be obtained, effective selection of yield components is imperative (Yahaya and Ankrumah, 2015). The importance of association among yield components and also with yield itself cannot be over emphasized in soya-bean breeding programme. Several studies have been conducted to identify the yield components of soya-bean yield and the results vary greatly. Ulloa *et al*. (2010) demonstrated number of branches in a plant, pods per plant, seeds in a pod and 100 seed weight influencing yield potential. Ghanbari *et al*. (2018) conducted a similar study focusing on biological yield, harvest yield, number of pods in a plant and number of branches and found them having influence on the yield.

Soya-bean cultivars are introduced in Lesotho for evaluation of yield and adaptability and no study has been conducted on yield and yield components, particularly when cultivars differ greatly on their ability to partition photosynthates and accumulate dry matter. This study is conducted with the following objectives; (i) establishing the differences among the soya-bean cultivars in terms of parameters measured (ii) to estimate the regression coefficients for yield components (iii) determining correlation among traits influencing yield of soya-bean.

MATERIALS AND METHODS

Study area

The study was conducted at Roma Campus of the National University of Lesotho which is situated 34km south west of Maseru, the capital city of Lesotho. The coordinates for Roma campus are 29^0 26’ 48 south latitude and 27^0 42’ 29 east longitude, with an altitude of 1610m above sea level. Temperature increases gradually in August from 20^o C during the day and 14^o C during the night to January when it reaches the highest temperature of 32^oC during the day and 23^oC at night, thereafter it declines to -7^oC in May and July. The average annual rainfall is 750mm commencing in October and reach the peak in February. Normally, it is dry from May to August. Snowfall is experienced in May to July. Hailstorm may occur at any time during the growing season, particularly in summer, autumn and spring,

Site description

Roma valley is broad, fertile and surrounded by sand stone cliffs topped to the east. The soil type consists of Berea series (Plinthaquic dystruchrepts). Top soil is a sandy loam with hue of 10 YRS, 4/3 while sub-soil is dark yellowish sandy clay loam with hue of 10yrs 4/4. The soil analysis results revealed pH 3.63 with phosphorus of 0.033 and 0.000 at 0ppm, 0.197 at 1ppm, 0.223 at 2ppm, 0.329 at 3ppm and 0.525 at 4ppm.

Experimental design

The experiment was carried out in a Randomized Complete Block Design with 28 treatments (soya-bean genotypes) and three replications. The size of the field was 36m x 17.2m equivalent to 619.2m^2 which was divided into 3 blocks where each block had 28 plots. Each plot had 4 rows with the length of 4m each. The inter-row and intra-row spacing were 0.9m and 0.15m, respectively. Soya-bean seeds used in experiment were obtained from the Agricultural Research Council – Grain Crop Institute in Potchefstroom, South Africa.

Agronomic practices

The land was first prepared using a tractor mounted mould-board plough, after which a disc harrow was used to level the seedbed and break the clods. A compound fertilizer of 2:3:2(22) + Zn was applied by hand over the field at the rate of 250kg ha^{-1} as basal dressing. Top-dressing was not applied. Sowing of seeds was done by hand. The field was irrigated twice a week due to prolonged drought that prevailed. Weeding was done by hand-hoeing thrice during the growing period of the soya- beans to control nutsedge (*Cyprus esculentum* L.) which was very problematic. Cape Mount rifles (*Mylabris spp.*) feeding on flowers of the plants was controlled chemically by applying ripcord (Cypermethin).

Data collection

Five soya-bean plants along the two middle rows in each plot were randomly selected and tagged with small card by thread, from where all measurements were taken throughout the growing period. There were eight yield components being recorded, namely; 100 grain weight, plant height, number of pods per plant, number of leaflets, leaflets size and leaflet shape.

Data analysis

Data collected were subjected to analysis of variance using GENSTAT Version 20 to establish the differences among soya-bean cultivars, after which least significant difference was employed. Multiple Linear regression and Pearson correlation of coefficient were performed.

RESULTS

Analysis of Variance

Analysis of variance depicted in Table 1 revealed highly significant difference ($P<0.001$) among soya-bean cultivars for plant height, weight per plot and weight of 100 grains, while no significant differences were observed among leaf shape, number of pots per plant and leaf size. Soya-bean cultivars with tallest height were NS 5590R, LS 6851R, PAN 1521 and LS 6860R measuring 92.25 cm, 95.25 cm, 94.25 cm and 92.25 cm, respectively. The shortest heights were exhibited by SST 6560, P71T74R, NS 5909R and P71TAR recording 54.5cm, 54.5cm, 56.75cm and 57.25cm, respectively. Highest weights per plot were obtained from in LDC 59 with an amount of 3,276 kg, followed by PAN 1555 with 3,051kg, DM 5302 with 3.04 kg and LS 6851 R with amount of 2.954 kg. The cultivars experiencing highest values in a weight of 100 grains were PAN 1575 with 16.73g, PAN 1555 with 16.58g, DM 5302 with 16.55g and LDC with 16.55. Within each of these

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variables which expressed highly significant differences, there were wide ranges from lowest to highest with some share values.

Table 1: Analysis of variance for yield and yield components

Source of variation	Df	Mean square					
		Leaflet shape	Plant height	No. of pots/plant	Weight per plot	Weight per 100grains	Leaf size
Replication	2	1.665	124.56**	1354.224	0.712**	5.593**	0.832
Cultivars	27	0.333	1033.70	860.083	6.225	2.521	0.905
Error	54	1.617	77.137	1339.935	0.507	0.273	0.510
Total	83						
Mean			76	194.560	1.445	14.136	4.619
CV							
LSD							
R^2			0.566	0.346	0.536	0.916	0.469

**Highly significant

Regression analysis

Table 2 and Table 3 below show a highly significant (P<0.01) regression for plant height, with the regression coefficient of 0.568 followed by leaflets shape (0.126). As plant height increased by one unit, yield increased by 0.568. Similarly, as plant height decreased by one unit, yield decreased by 0.568. Increase of leaflet shape by one unit increased yield of soya-bean by 0.126. Likewise, decrease in leaflet shape by one unit decreased yield of soya-bean by 0.126. Leaflets size, number of pods per plant and weight of 100 grains made an insignificant contribution towards soya-bean yield. The linear model below expresses the impact of the independent variables (regressors) on the dependent variable (regressant).

Table 2: Analysis of variance for Regression Analysis

Source of variation	Df	Sum of squares	Mean square	F ratio	Significance
Regression	5	22.494	4.499	9.599	0.000[b]
Residual	78	36.555	0.469		
Total	83	59.049			

$$Y_S = \mu + \beta_1 (x_1) + \beta_2 (x_2) + \beta (x_3) + \beta (x_4) + \beta (x_5) + \mathcal{E}$$

where Ys is soya-bean yield (regressant), μ=Overall mean, β=regression coefficients,
X = variable (regressor), Ɛ = error term

$$Y_S = 3.556 + 0.012(x1) + 0.126(x2) + 0.568 (x3) + 0.085(x4) + 0.078 (x5) + 0.685$$

Table 3: Regression coefficients for parameters studied

Model	Standardized coefficients (β)	t-value	Significance
Constant	3.556	3.038	0.003**
Leaflets size	0.012	0.127	0.899
Leaflets shape	0.126	1.303	0.197
Plant height	0.568	5.905	0.000**
No. of pots/plant	0.085	0.891	0.376
Weight of 100grains	0.078	0.794	0.430

Correlation among the parameters

Seed yield per plot was highly correlated (0.864) with number of pods per plant, plant height (0.724), seed per pods (0.796) and seed weight per pod (0.751) while moderately correlated was observed in 100 seeds weight (0.677). Plant height was highly correlated (0.618) with 100 seed weight and seed weight per pod (0.625), and moderately correlated with number of pods per plant (0.531). Seed per pod revealed low correlation (0.375) with plant height. Number of pods per plant was highly correlated (0.869) seed per pod and moderately correlated with 100 seed weight and seed weight per pod (0.416). Number of pods per plant was moderately correlated with 100 seeds weight (0.497) with seed weight/pod (0.559). Seeds per pod were moderately correlated (0.396) with 100 seed weight while seed weight per pod also was moderately correlated to 100 seed weight (0.481). The correlation matrix in table 4 below displays coefficient of correlation.

Table 4 Correlation coefficient matrix for parameter studied

	No. of pods/plant	Plant height	Seeds/pod	100 seeds weight	Seed weight/pod	Seed yield/plot
No. of pods/plant	1.00	0.531	0.869	0.497	0.559	0.864
Plant height	0.531	1.00	0.375	0.618	0.625	0.724
Seeds/pod	0.869	0.375	1.00	0.396	0.416	0.796
100 seeds weight	0.497	0.618	0.396	1.00	0.481	0.677
Seed weight/pod	0.559	0.625	0.416	0.481	1.00	0.751
Seed yield/plot	0.864	0.724	0.796	0.677	0.751	1.00

DISCUSSION

Analysis of variance

Highly significant differences among the soya-bean cultivars for plant height, weight per plot and weight of 100 grains implied that there were variabilities that could be explored from the cultivars expressing high values. A similar response was observed with different genotypes in field studies conducted in Bangkok (Sarutayophat, 2012) and Brazil (Wei and Molin, 2020). Plant breeders could use cultivars with these desirable traits that have direct and indirect effects on seed yield in selection for breeding of high yielding cultivars.

Regression analysis

Observation of the regression analysis shows that plant height was the most parameter that contributed immensely on the yield of soya-beans with the highest and highly significant regression coefficient. This was similar to Ghanbari *et al*., (2018) and Li *et al.,* (2020) findings who also concluded that plant height is among the traits contributing indirectly to high soya-bean yields. Furthermore, Sarutayophat (2012) also suggested that plant height is one of the important trait to be considered in selection for breeding of high yielding soya-bean cultivars.

Correlation coefficient

Correlations among all characters under studied were high ranging between r =0.5 and r = 0.8 except for seeds/pod and plant height, seed per pod and seed weight per pod which were moderately correlated (r = 0.357 to 0.497). The correlations for all characters were positive. This showed that as one character was increased, the others also increased. But they were increasing at different rates because of their differing correlation coefficients. Some characters had very strong linkage to the others swinging towards the same direction. Conversely, some characters exhibited moderate linkage implying that they move at different rates. Nonetheless, no one character affected the other negatively or inversely. These observations indicate that improvements in each of the traits would lead to overall improvements of the other trait. Thus, such correlations help in making informed decisions for selection of traits controlled by multiple genes (Aman *et al*., 2020). The highest direct positive effect on seed yield per plot was exhibited by number of pods per plant. This is in agreement with several other researchers who proved that total number of pods is one of the main yield determining factors in soybeans (Ball *et al*., 2001; Board *et al*., 2003; Liu *et al*., 2010; Sarutayophat, 2012).

Quantitative traits like seed yield express themselves in close association with many other traits. Change in the expression of one trait is usually associated with changes in the expression of many other traits. Therefore, the correlations obtained in the present study are useful in the selection of traits having direct and significant correlation in improving grain yield.

CONCLUSION

The relationships of characters on economic yield are the primary important data in breeding programs. It can be suggested that improvements in grain yield of soybean can be accomplished through selections based on the findings from the current study. Hence, knowledge of associations between yield and its component traits as well as among the component traits themselves can promote the efficiency of selection in soybean breeding programs. It is well established that correlation and regression studies between yield and yield components are pre-requisite in planning effective breeding programs. These findings imply that effective Soya-beans seed yield improvement depends on simultaneous improvements in all yield components. Selection efforts based on grain yield alone are often less effective and efficient (Mohammadi *et al*., 2003).

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