Evaluation of Some Concomitant Yield Variable in Some Improved Soybean (Glycine Max (L) Merr) Varieties

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Abstract
In this study, ten newly developed early maturing soybean varieties were considered. Among all the agronomic parameters of a leguminous crop, eight were considered and they are the following: days to flowering, days to maturity, height at harvest, height at lowest pod, number of plant harvested, dry fodder weight, 300 seed weight and nodulation count. Their effect on plant yield were evaluated and the result showed that among all the tested parameters, number of plant harvested and dry fodder weight are the parameters that are significantly and linearly related to the plant yield with correlation coefficient (r), r = 0.902 and 0.834 and are significant at 0.1% and 1% levels of significant respectively.

To critically examine the effect of these agronomic parameters on the yield variable, analysis of variance and analysis of covariance were carried out separately on them and it was found out that the varietal effect on the adjusted yield (the yield adjusted with related covariates) was not significantly different, unlike the unadjusted yield or the yield adjusted with non-related covariates.

Keyword:correlation analysis, analysis of variance, analysis of covariance, concomitant variables

1. Introduction

Soybean (Glyeine Max (L) Merr) is a member of leguminous family. Its production is being encouraged in many sub-Saharan African countries because of the high nutritive value of its grains. As was earlier stated, being a legume, soybean has the potential of fixing atmospheric nitrogen thus enhancing the fertility of soils in which it is grown.

A way of encouraging and sustaining the interests of farmers who grow this relatively new crop in this part of the world, would be to ensure that improved cultivars with potentiality high and stable yield are made available for them for planting. In order to accomplish this objective, stability of performance should be considered as part of the selection criteria in a soybean breeding programme intended for the development of cultivars meant for growing in variable environment as exist in tropical Africa.

Furthermore, soybean being highly suitable for human consumption and animal feed and its excellence source of protein it is commercially cultivated crop in Nigeria especially in middle belt.

Oyekan and Ayeni (1992) reported that, its production level had gradually increased from what it was before the Nigerian Civil War, as more farmers and new area are being involved in its production.

Also, the development and release of new genotypes that replaced the low yielding 'Malayan' variety leads to tremendous increase in its production. These improved varieties though specifically released for large-scaled production (Oyekan *et al*, 1986), small-scaled farmers took the advantage of them because of their yield and agronomic potential. One of the problems facing soybean production is the yielding as a result of pest and diseases poor adaptation and non-availability of improved soybean varieties. But this study aims as assessing yield-contributing traits that will linearly influence its yield potential to enhance good selection.

The use of correlation and covariance analysis was reported by Le Clerg *et al*. (1962). According to them, covariance analysis is a technique for testing homogeneity of data that involve two or more concurrent variables but unaffected by the treatment. Kuehi (2000) similarly reported that in covariance analysis, values for treatment means in the research study depends on covariates that vary among the experimental units and have significant relationship with the primary response variable. It is believed that concomitant variables or covariates can be measure at anytime in an experiment and their influence on the response variable can be assessed by analyzing the data, using combined covariance regression methodology with analysis of variance.

The objective of this study is to test for the presence of possible correlation between yield and some selected agronomic characteristics, use the analysis of covariance to evaluate the effect of the selected agronomic characteristics that are actually covariates soybean yield and lastly estimate yield under adjusted and unadjusted effects of concomitants variables.

1.1 The Linear Model for the Analysis of Covariance in Randomized Complete Block Design

The model for the randomized complete block design used in this study can be expressed as:

$$Y_{ii} = \mu + T_i + \rho j + \beta(X_{ij} - X_{..}) + e_{ij}$$

Where $i = 1, 2, \ldots t$ and $j = 1, 2, \ldots r$

Y_{ij} = Soybean Yield

X_{ij} = each covariates (agronomic parameters)

μ = the general (grand) mean

T_i = treatment effect

ρ_j = block effect

β = the regression of Y_{ij} on X_{ij}

e_{ii} = NID error with $(0, \sigma_e^2)$, NID means Normally Independently Distributed

1.2 Assumption of Covariance Analysis

a. Fixed X values, measured without error and independent of treatment and block effects. That is X values that are not affected by treatments and blocks before measurements were made.

b. The regression coefficients for each treatment are identical.

c. The treatment effects and block effects, all sums to zero in each cases i.e.

$$\sum_{i=1}^{t} T_i = 0 \qquad \sum_{j=1}^{r} \rho_j = 0$$

d. The slope $\beta \neq 0$ and the relationship between Y_{ij} and X_{ij} is linear.

e. It is also assumed that the residuals are normally independently distributed with zero means and common (Constance) variance.

That is e_{ij} = NID (0, σ_e^2) where e_{ij} represents experimental error. NID represents Normally and Independent Distributed, mean = 0 and Constance (common) variance of error = σ_e^2

3. Materials and Methods

This research work was carried out at the Institute of Agricultural Research and Training Moor Plantation, Ibadan, Nigeria, under the National Coordinated Research Project on Soybean Early. Ten newly developed early maturing soybean varieties were selected for this study. They include: TGX 1799-8F, TGX 1831-32F, TGX 1485-ID, TGX 1019-2EB, TGX 1805-17F, TGX 1805-8F, TGX 1830-20E, TGX 1871-12E, TGX 1835-10E and TGX 1740-2F.

Plating was done on the plot size of 4m within 2 rows with spacing of 0.5m. Weeds were chemically controlled using Galex (250g/l metobromuron + 250g/l metolachlor) and Gramoxone (300g/l paraquat) at 5lt and 2lt/ha respectively. This was however supplemented with a regime of hand weeding at six week after planting (WAP).

From the planting day through the harvesting, the participating scientists did not relent in collecting all the appropriate data on the agronomic parameters of this crop.

According to Le Clerg *et al*. (1962), a common error associated with covariance analysis, is the application of this technique without prior knowledge of the regression relationship of the response variable (yield) and the covariates (agronomic parameters). In order to avoid this error, the relationships between agronomic parameters and the grain yield was first evaluated on using the techniques of correlation analysis. The agronomic parameters that were linear and significant related with the grain yield of soybean were then subjected to the analysis of covariance. Before this, analysis of variance have been carried out on the experimental data to evaluate the varietal effect on yield and their pertinent means were separated through the Duncan Multiple Range Test popularly known as Duncan's Test (Duncan, 1955).

All the statistical analyses carried out in this study were run through the computer software for statistical analysis which includes: SPSS 9.0 and MSTAT-C.

4. Results and Discussion

The result of the analysis variance in Table 1 shows that, without adjusting the grain yield of soybean by the effect of any covariates, the effect of genotypic characters in each of these varieties (the varietals effect) were significantly different ($P<0.01$) on the grain yield of the crop.

This can be clearly seen as shown on the Table 2. Here, after separating the varietals means through Duncan's test, it was found out that TGX 1805-17F and TGX 1485-1D varieties produced the height grain yield which are not significantly different from each others, with the grain yield of 999.98Kg/ha and 816.83kg/ha respectively. But the lowest grain yield was produced by TGX 1019-2EB with the grain yield of 198.02kg/ha.

Table 1: F-Value from the Analysis of Variance for the Test of Varietals Effect of Soybean Varieties on its Grain yield Without Adjusting for any Covariate effect .

Source of variation	Degrees of Freedom	F-Values
Block	2	0.34487^{NS}
Variety	9	4.37128^{**}
Error	18	
Total	29	

Note: ^{NS} = Not Significantly difference at 5% α
** = Significantly difference at 1% α

Table 2: Means Varietal Effects of Soybean Varieties on their Grain Yield

Varieties	Varietal Means
1. TGX 1799-8F	314.3cd
2. TGX 1831-32F	524.75bc
3. TGX 1485-1D	816.83a
4. TGX 1019-2EB	198.02d
5. TGX 1805-17F	999.98a
6. TGX 1805-8F	316.83cd
7. TGX 1830-20F	762.38ab
8. TGX 1871-12E	539.60bc
9. TGX 1835-10E	471.78c
10. TGX 1740-2F	465.35
S.E.	80.25

Note S.E.= Standard Error of Means
Figure in the same column having different alphabet are significant difference at P<0.05

Furthermore, covariance analysis was carried out on the same yield but with covariates that were not significantly related with the grain yield as shown in Table 3. This shows that the varietals effect was also significantly difference on the grain yield (p<0.01), as with analysis of variance, but in actual sense this was wrong because it was wrong application of the analysis of covariance and this was a wrong inference.

Table 3: F-values From the Analysis of Covariance for the Test of the Varietals Effect of Soybean Varieties on its Grain After Adjusting for the Effect of each Covariate that are not significantly related with Grain Yield.

Source of Variation	Degree of Freedom	Days to Flowering	Days to Maturity	Height at Harvest	Height at Lowest Pod	300 Seed Weight	Nodulation Count
Block	2	0.723^{NS}	0.457^{NS}	0.212^{NS}	0.222^{NS}	0.437^{NS}	0.268^{NS}
Variety	9	5.118^{**}	4.084^{**}	4.064^{**}	4.022^{**}	3.896^{**}	3.761^{**}
Covariate	1	3.376	0.314	0.101	0.036	0.504	0.047
Error	17						
Total	29						

Note: ** = Significantly related with grain yield at 1% α
^{NS} = Not significantly different at 5% α.

Before this covariance analysis was carried out on the experimental data, correlation analysis as shown in Table 4 has been carried out between the grain yield and all other agronomic parameters. Among all these agronomic parameters, only the number of plant harvested per experimental plot and dry fodder weight of the crop are the agronomic parameters that were significantly related with the grain yield. Their correlation coefficients are 0.902.and 0.834 respectively and were significant at 0.1% and 1% level of significant respectively.

Table 4: The Result of Correlation Analysis of Grain Yield Against All The Agronomic Parameters.

Agronomic Parameters	Simple Correlation Coefficients (r)
1. Days to flowering	-0.046^{NS}
2. Days to maturity	-0.171^{NS}
3. Height at harvest	0.151^{NS}
4. Height of the lower pod	0.020^{NS}
5. Number of plant harvested	0.902^{***}
6. Fodder dry weight	0.834^{**}
7. 300 seed weight	-0.424^{NS}
8. Nodulation count	0.382^{NS}

Note: *** = Significantly related with grain yield at 0.1%α
** = Significantly related with grain yield at 1% α
^{NS} = Not significantly related at 5% α.

Although the results from the previous works carried out on the grain of soybean and some of its agronomic parameters according to Lehman and Lambert (1960); Weber *et al*. (1966); Hanway and Weber (1971) and Ramseur *et al* (1985) was that, dry matter accumulation and leaf area index (LAI) increases with plant population and narrow spacing, but grain yield was usually maximizes at row spacing that produced lower Dry Matter and Leaf Area Index. Also, Savoy *et al*, (1992) reported that in some early maturing varieties yield related components such as plant height, and dry matter accumulation have a significant contribution on yield.

Sequel to the result obtained from the correlation analysis, covariance analysis was further carried out and the result of this analysis obtained from the experimental data as shown in Table 5, shows that only the covariates that were significantly related with the grain yield of soybean are the ones that have varietals effect not significantly affecting the grain yield after adjusting this yield variable by the effect of these covariates.

Table 5: F-values From the Analysis of Covariance for the Test of the Varietals Effect of Soybean Varieties on its Grain After Adjusting for the Effect of each Covariate that are significantly related with the Grain Yield.

Source of Variation	Degree of Freedom	Number of Plant Harvested	Dry Fodder Weight
Block	2	2.113^{NS}	0.046^{NS}
Variety	9	2.024^{NS}	1.902^{NS}
Covariate	1	26.928	4.944
Error	17		
Total	29		

Note: ^{NS} = Not significantly different at 5% α.

This implies that, the contributing effects of genotypic characteristics in all the varieties on their grain yield were the same if factors like plant population or food supply to the crop are kept constant or controlled in all these varieties. This could be achieved, if for all these varieties, from the planting day through the harvesting period in the experimental area or farmland are free from the attack of pests and diseases and the cultivation of these new breeding lines (varieties) meets all the necessary conditions for their cultivation.

The varietals means adjusted with the effect of plant population as show in Table 6, shows that TGX 1871-12E produced the height grain yield with 675.22kg/ha grain yield, but the least grain was yield produced by TGX 1740-2F with 350.21kg/ha grain yield, though the covariance analysis result, as shown in Table 5 shows that they are not significantly different from each other.

Also as shown in Table 6, the varietals means adjusted with the effects of dry fodder weight shows that, TGX 1805-17F produced the height grain yield with 849.50kg/hagrain yield, but the least grain yield produced by TGX 1019-2EB with 322.87kg/ha grain yield. Also in this case the varietals means are not significantly difference from one another as show in the result of covariance analysis in Table 5.

Table 6: Means for the Varietal Effect of Soybean Varieties on their Yield After Adjusting for the Effect of the Covariates

Variety	Grain yield (kg/ha) After Adjusting For: Number of Plants Harvested	Dry Fodder Weight
1. TGX 1799-8F	618.55	436.27
2. TGX 1831-32F	434.49	456.20
3. TGX 1485-1D	632.52	795.21
4. TGX1019-2EB	463.12	322.87
5 TGX 1805-17F	458.43	849.50
6. TGX 1805-8F	493.09	429.96
7. TGX1830-20F	633.02	579.65
8. TGX 1871-12E	675.22	605.86
9. TGX 1835-10E	662.26	509.63
10. TGX 1740-2F	350.21	421.76
S.E.	61.853	80.544

Note S.E.= Standard Error

These were computed from the effective error means squares.

But with the covariates where correlation analysis shows that they are not significantly related with the grain yield, the result of their covariance analysis as shown on Table 3 shows that, their varietals effect on grain yield were significantly difference. But these in actual sense were not true because, this is wrong application of covariance analysis as stated earlier.

The reason was that, any covariate that the correlation analysis showed not to have significance relationship with the response (dependant) variable, even after adjusting their effect on the response variable, the resultant result cannot be significantly different from the result of the analysis of variance as shown in Table 1, where the response variable was not adjusted. This now shows why it is necessary to first carry out correlation analysis between the response variable and the covariates before carrying out the analysis of covariance on any experimental data.

5. Conclusion

This study afforded us to see the need for intensifying our efforts in the control of pests, diseases, environmental, soil, climatic, and other ecological factors that causes change in plant population and dry fodder weight in these new soybean genotypes. This is because, among all the agronomic parameter tested, it was only plant population and dry fodder weight that highly influence the grain yield of these soybean varieties. Hence, care must be taken not to have anything cause hazard effect on them.

Also, we now see the need to first evaluate the degree of relationship between our response variable(s) and the concomitant variables before carrying out the analysis of covariance on them.

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