INFLUENCE OF ENVIRONMENT ON PROTEIN AND OIL CONTENTS OF SOYBEANS SEED
(GLYCINE MAX (L.) MERRIL)

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ABSTRACT

An attempt was made to study the magnitude of environmental variability on protein and oil contents of six genetically diverse soybean genotypes under three environments represented by three locations in Nigeria (Zaria in Northern Guinean Savanna, Jos in Pseudo Savanna and Mokwa in Southern Savanna) for two years (1996 and 1997). Significant genotypic location and location x genotype x year effects were observed for protein content while genotypic and location x genotype effects were significant for oil contents. Significant genetic differences in protein content occurred among genotypes, locations and between years, whereas significant genotypic differences in oil content was observed. Bossier and TGX849-313D out yielded in protein content. Protein content in Mokwa and Zaria were higher than that of Jos while protein content in Year 2 (1997) was higher than Year 1 (1996). Oil content remained similar irrespective of location and year. Jos is in a dry cool environment compared with Mokwa which is humid and hot and Zaria which is dry and hot. Environmental factors exerted greater influence more on the protein content than oil content of tropical soybean seeds. High temperature tended to increase protein content with little or no effect on oil content. There was positive significant association between protein and oil contents under Jos environment in 1997 whereas the association was negatively significant under Mokwa environment. Therefore, selection for protein and oil contents among soybean genotypes for further improvement is possible due to large variability present. Variations in protein and oil contents were due to differences in location. Changes in climatic factors resulting from yearly cultivation of soybean in different locations can influence protein content.

KEY WORDS: correlation analysis, genotype, Glycine max, oil, protein

INTRODUCTION

Most oil seed improvement places major emphasis on high-yielding cultivars that are both high in oil and protein contents. Although historically considered to be oil crops, soybean contributes significantly to the world supply of vegetable protein. The soybean oil is 20% of the seed and it is high in essential fatty acids and devoid of cholesterol. Soybean is also a source of high quality and inexpensive protein which is about 40% of the seed (Anon, 1987).

Quality of many crops is influenced by various component characters which are greatly affected by the conditions under which they are grown, some of which can be managed by man. Protein and oil qualities

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and quantities, particularly quantities are
influenced by environment and heredity
(Bates and Heyne 1980, Gourley and Creech
1980).
Several attempts have been made to improve
soybean quality by manipulating agro-
ecological conditions. According to Allard
and Bradshaw (1964), the magnitude of
variety and environment interaction is
important in predicting gains in selection
experiments. It also determines the number
of years and locations that are required to
reach a desired level of precision in selection.

Field studies of soybean cultivars grown in a
number of locations for several years showed
that oil content increased as protein content
decreased (Gourley and Creech 1980).
Genetic variability for oil and protein contents
has been confirmed in many other cultivated
oil crops such as peanut, safflower, sesame
in which large number of cultivars of the
same species have been screened (Gourley
and Creech 1980). The variations in oil and
protein contents of crops grown at several
agro-geographical location have been
reported by Dybing and Zimmerman (1965);
Manopharan et al., 1993. Considerable
variation was reported in oil content in
soyabean (Gourley and Creech, 1980), this
variation was not due to difference among
cultivars, as the same cultivar was grown on
each site. One could also expect year-to-
year variation in oil quality and quantity. A
linear increase in soyabean oil to increase in
temperature was reported by Howel and
Cartter (1953). Environmental effects on
quantity of lipids generally occur in the
developing seed only within the few weeks
between flower fertilization and maximum
dry weight accumulation. Oil contents
appears to be more affected by non-genetic
sources of variations (Manopharan et al.,
1993).

Although several reviews in recent years
have explored quality and quantity of protein
and oil in relation to many factors in plants,
little or no information is available on the
effect of location on protein and oil contents
in tropical soybean. Also little is known
about the relative quantity of protein and oil
in soybean sown in a particular location over
a two year period. An attempt was therefore
made to study the magnitude of
environmental effect on protein and oil
contents of tropical soybean under six
environments represented by three locations
and two years.

MATERIALS AND METHODS

The research materials consisted of seeds of
six diverse soybean genotypes. BOSSIER,
TGm 7_{7}7p, TGx530-02D, TGx849-313D,
TGx923-2E and TGx1448-2E obtained from
IITA, Ibadan, Nigeria. The seeds were grown
in Mokwa, (Southern guinea savanna), Zaria,
(Northern guinea savanna) and Jos (a
pseudo-savanna region) Nigeria in the 1996
and 1997 cropping seasons (Table 1).

At each agro-ecological location and in each
year, planting was done in four rows plots of
6m long and an inter-row spacing of 75cm in
a 3x6x2 factorial design fitted into
randomised complete block design. Plots
were sown by drilling. On emergence,
seedlings were thinned down to a within-row
spacing of 5cm leaving a plant population of
about 480 plants per plot. Compound
fertilizers, NPK 15:15:15 and single
superphosphate at the rate of 7.5kg N and
67.5kg P_{2}O_{5} per ha were applied and
incorporated during land preparation in each
experimental site. Land was prepared by
ploughing and harrowing. Weed control was
 carried out according to the recommended
cultural practices peculiar to the local
conditions (IITA, 1989).
Table 1: Mean rainfall, mean temperature and mean relative humidity in Mokwa, Zaria and Jos between June and October. 1996 and 1997

<table>
<thead>
<tr>
<th>Month</th>
<th>Mokwa (9°18'N, 5°03'E) (152m)</th>
<th>Zaria (11°06'N, 7°44'E) (686m)</th>
<th>Jos (9°54'N, 8°55'E) (1400m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Temp (°C)</td>
<td>Rainfall (mm)</td>
<td>RH (%)</td>
</tr>
<tr>
<td>Year 1 (1996)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>28.8</td>
<td>71.3</td>
<td>70.0</td>
</tr>
<tr>
<td>July</td>
<td>29.4</td>
<td>201.0</td>
<td>77.5</td>
</tr>
<tr>
<td>August</td>
<td>28.9</td>
<td>135.0</td>
<td>75.0</td>
</tr>
<tr>
<td>September</td>
<td>29.9</td>
<td>282.3</td>
<td>81.5</td>
</tr>
<tr>
<td>October</td>
<td>29.8</td>
<td>145.5</td>
<td>75.0</td>
</tr>
</tbody>
</table>

*Mean of daily values at 13.00 hour, local time.
+Altitude of sites in metres
Temp. and Rainfall data were collected on the field. Rainfall data were collected from the nearest weather station in the three locations.

Table 2: Mean square values of the combined analysis of variance of protein and oil contents of soyabean genotypes evaluated during 1996 and 1997 at Mokwa, Jos and Zaria

<table>
<thead>
<tr>
<th>Source of Variation</th>
<th>DF</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replication</td>
<td>2</td>
<td>1.74 ns</td>
<td>4.20*</td>
</tr>
<tr>
<td>Location</td>
<td>2</td>
<td>10.08*</td>
<td>2.03 ns</td>
</tr>
<tr>
<td>Error (a)</td>
<td>10</td>
<td>2.02</td>
<td>2.78</td>
</tr>
<tr>
<td>Genotype</td>
<td>5</td>
<td>24.43**</td>
<td>5.67**</td>
</tr>
<tr>
<td>Loc X Geno.</td>
<td>10</td>
<td>7.44*</td>
<td>4.13*</td>
</tr>
<tr>
<td>Error (b)</td>
<td>24</td>
<td>5.31</td>
<td>3.04</td>
</tr>
<tr>
<td>Year</td>
<td>1</td>
<td>14.74*</td>
<td>1.36 ns</td>
</tr>
<tr>
<td>Geno X Year</td>
<td>5</td>
<td>4.12</td>
<td>1.48 ns</td>
</tr>
<tr>
<td>Loc X Year</td>
<td>2</td>
<td>3.29</td>
<td>1.32 ns</td>
</tr>
<tr>
<td>Geno X Loc. X year</td>
<td>102.33 ns</td>
<td>0.91 ns</td>
<td></td>
</tr>
<tr>
<td>Error (c)</td>
<td>36</td>
<td>2.82</td>
<td>4.79</td>
</tr>
</tbody>
</table>

C.V. (%) 13.91 14.30

*, ** Significant at 0.05 and 0.01 probability levels respectively
ns = not significant

Mean squares from a combined analysis of variance of protein and oil contents of the soyabean genotypes evaluated in the three locations over a two-year period is presented in Table 2. Highly significant genotypic differences were observed for both protein and oil contents. Significant location, location x genotypes and year effects were also observed for protein content. However, only the location x genotype effect was significant for oil content in addition to the

The protein and oil contents were determined at harvest maturity. The harvested soybean pods were hand threshed to avoid mechanical damage of seeds. Seeds of all harvested plants in the two middle rows in each environment were dried to about 10% moisture content and bulked for protein and oil content determinations. Twenty seeds of each of the six genotypes were ground in a "Moulinex" blender at speed no. 2 for an average of 1.2 minutes per sample. The ground seed samples (flour) were used for the protein and oil analyses. The total crude protein of the seeds was determined by the Micro-kjeldahl method (N x 6.25) as outlined by AOAC (1980) while the oil content was estimated by Nuclear Magnetic Resonance Method (Gupta et al., 1985) at ILTA, Ibadan, Nigeria. The values generated were
expressed in percentages.

Statistical analysis: Analysis of variance was carried out separately for each parameter as suggested by Steel and Torrie (1980). Mean values were separated using Duncan multiple range test. Simple correlation analysis was done for the two parameters under the three locations and two years.

RESULTS AND DISCUSSION

highly significant genotypic differences. The highly significant differences among genotypes for both traits suggest, therefore, that selection for protein and oil contents among soybean genotypes for further improvement is possible due to large variability present. Significant location x genotype interaction effects also suggest that variations in protein and oil contents among the selected soybean varieties were due to difference in location (Table 2).

However, there was significant effect of year and location for protein content whereas there was none for oil content, suggesting that changes in climate resulting from yearly cultivation of soybeans in different locations can influence its protein content whereas oil content remains unchanged whether there is a change in year and location or not.

Significant differences among block for oil content indicate that experimental blocks were not homogenous (Table 2). Although, the genotype x year, location x year and genotype x location x year interaction were not significant, the relatively low coefficients of variability for the two characters measured were an indication that experimental error was low and thus, selection for protein and oil contents could be done with greater reliability.

Mean values for protein and oil contents of soybean genotypes evaluated in three locations over the two year period is shown in Table 3. Significant genetic differences in protein content were observed among genotypes, locations and between years whereas significant genotypic (and not location and year) differences in oil content were observed. For instance, mean protein content was highest for BOSSIER (41.17%) followed by TGx849-313D (41.13%) and lowest in TGx737p (38.68%). Mean protein contents in Mokwa and Zaria were statistically similar and higher (40.22%) than what obtained in Jos (39.31%). Mean protein content was also lower in year 1 (39.54%) than in year 2 (40.29%) (Table 2). Mean oil content was highest for TGx536-02D (19.60%) followed by TGx923-2F.

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mokwa</th>
<th>Jos</th>
<th>Zaria</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSSIER</td>
<td>40.33c</td>
<td>41.47a</td>
<td>41.70a</td>
<td>41.17a</td>
</tr>
<tr>
<td>TGx737p</td>
<td>39.00d</td>
<td>39.13d</td>
<td>37.92c</td>
<td>38.68b</td>
</tr>
<tr>
<td>TGx849-02D</td>
<td>40.78b</td>
<td>36.77f</td>
<td>38.93d</td>
<td>38.83b</td>
</tr>
<tr>
<td>TGx849-313D</td>
<td>42.00a</td>
<td>40.55b</td>
<td>40.83c</td>
<td>41.13a</td>
</tr>
<tr>
<td>TGx923-2F</td>
<td>40.47b</td>
<td>39.90c</td>
<td>41.37b</td>
<td>40.58a</td>
</tr>
<tr>
<td>TGx1448-2F</td>
<td>38.78d</td>
<td>38.03e</td>
<td>40.58c</td>
<td>39.13b</td>
</tr>
</tbody>
</table>

Mean 40.23a 39.31b 40.22a

<table>
<thead>
<tr>
<th>Year 1</th>
<th>Year 2</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>BOSSIER</td>
<td>41.34a</td>
<td>40.99a</td>
</tr>
<tr>
<td>TGx737p</td>
<td>38.24c</td>
<td>39.12b</td>
</tr>
<tr>
<td>TGx849-02D</td>
<td>37.63d</td>
<td>40.02a</td>
</tr>
<tr>
<td>TGx849-313D</td>
<td>40.85b</td>
<td>41.40a</td>
</tr>
<tr>
<td>TGx923-2F</td>
<td>40.09a</td>
<td>41.07a</td>
</tr>
<tr>
<td>TGx1448-2F</td>
<td>39.13bc</td>
<td>39.13b</td>
</tr>
</tbody>
</table>

Mean 39.54a 40.29a

Means with similar alphabets along the column and row are not significantly different at probability of 0.05
Jos a pseudo-savanna region of Nigeria is in a dry cool environment compared to Mokwa which is humid and hot and Zaria which is dry and hot. The current observations do not support an earlier report of Howell and Cartler (1953) who observed that high temperature increases oil content in soybean. They are neither in consonance with report of Manopharan et al., (1993) who observed that oil content is more affected by non-genetic sources of variation. Rather, high temperature tends to increase protein content with little or no effect on oil content in the current study. This is probably because more protein than oil was accumulated at 24-40 days after anthesis (Rubel et al., 1972) in the soybean genotypes evaluated.

The correlation analysis of protein with oil contents showed a positive and significant association (P < 1%) in year 2 (1997) under Mokwa environment. Conversely, protein content had a negative and significant association (P < 5%) with oil content under Jos environment in year 2 (1997). In Zaria, however there was no association between protein and oil contents.

Characters which are correlated with oil yield will indicate the reliability of these characters in selecting for protein yield. This will no doubt facilitate breeding effort. This is true of the association of protein content with oil content in this study in 1997 under Jos environment. The fact that protein and oil contents were negatively correlated indicates that by selecting for variety with low oil content one is indirectly selecting for high protein. The variation in the relationship of protein with oil content in the two years might be due to the variation in the weather conditions. The increase in the amount of rainfall, temperature and relative humidity recorded in 1997 especially in Mokwa and the relative humidity and temperature

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Mukwa</th>
<th>Jos</th>
<th>Zaria</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bossier</td>
<td>18.35b</td>
<td>20.33a</td>
<td>17.92d</td>
<td>18.87ab</td>
</tr>
<tr>
<td>TGm 737p</td>
<td>18.13bc</td>
<td>20.33a</td>
<td>18.99e</td>
<td>18.05b</td>
</tr>
<tr>
<td>TGx 536-02D</td>
<td>19.02a</td>
<td>17.03c</td>
<td>19.30a</td>
<td>18.61a</td>
</tr>
<tr>
<td>TGx 849-313D</td>
<td>17.73c</td>
<td>20.48a</td>
<td>19.00a</td>
<td>18.33b</td>
</tr>
<tr>
<td>TGx 923-2E</td>
<td>18.33b</td>
<td>18.27b</td>
<td>18.82c</td>
<td>18.44ab</td>
</tr>
<tr>
<td>TGx 1448-2E</td>
<td>19.12a</td>
<td>18.17b</td>
<td>19.18ac</td>
<td>19.04ab</td>
</tr>
<tr>
<td>Mean</td>
<td>18.45a</td>
<td>18.82a</td>
<td>18.87a</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mokwa</td>
<td>18.77a</td>
<td>18.12a</td>
<td>18.45a</td>
</tr>
<tr>
<td>Jos</td>
<td>18.88a</td>
<td>18.82a</td>
<td>18.85a</td>
</tr>
<tr>
<td>Zaria</td>
<td>18.84a</td>
<td>18.89a</td>
<td>18.87a</td>
</tr>
<tr>
<td>Mean</td>
<td>18.83a</td>
<td>18.61a</td>
<td></td>
</tr>
</tbody>
</table>

Means with similar alphabets along column and row are not significantly different at probability of 0.05 (15.04%) and lowest for TGx737p (18.05%). However, mean oil content remained similar irrespective of location and year (Table 3).

As far as protein content is concerned, Mokwa and Zaria locations were similar in their performance when averaged over the two-year period whereas Jos location was outstanding with relatively lower protein content. However, changes in location over the two year period did not affect oil content of soybean genotypes. The observations above suggested that environmental factors exerted greater influence more on the protein content than oil content of tropical soybean seeds.
recorded between the time seeds matured and the harvest periods, might account for the correlation observed in 1997 in Jos and Mokwa. Harris et al., 1965 have earlier reported that high temperature at developmental stage is detrimental to subsequent seed protein and oil.

Appendix I: Correlation co-efficient values between protein and oil contents of soybean under different environments

<table>
<thead>
<tr>
<th>Protein (%)</th>
<th>Oil content (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 1 (1996)</td>
</tr>
<tr>
<td>Jos</td>
<td>-0.443 ns</td>
</tr>
<tr>
<td>Zaria</td>
<td>-0.563 ns</td>
</tr>
<tr>
<td>Mokwa</td>
<td>-0.381 ns</td>
</tr>
</tbody>
</table>

* = Significant at 5% level of probability
** = Significant at 1% level of probability
ns = not significant

REFERENCES


