GLOBAL JOURNAL OF AGRICULTURAL SCIENCES VOL. 1, NO. 1, JANUARY 2002: 27-32

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

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(Received 2 November 2000 ; Revision accepted 31 January, 2001)

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 Guinea 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 soybean 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 737p, 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_2O_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 loca 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

Month	Mokwa 9°18'N, 5°03'E (152m)⁺			Zaria (11°06'N, 7°44'E) (686m)⁺			Jos (9°54'N, 8°55'E (1400m)⁺		
	Temp (°C)	Rainfall (mm)	RH* (%)	Temp (°C)	Rainfall (mm)	RH* (%)	Temp (°C)	Rainfall (%)	RH* (mm)
Year 1 (1996)									
June	28.8	71.3	76.0	26.3	155.8	62.4	25.5	128.7	58.3
July	29.4	201.0	77.5	24.9	269.0	67.6	24.3	301.8	70.4
August	28.9	135.0	75.0	24.0	300.9	72.0	24.9	140.5	60.5
September	29.9	282.3	81.5	24.8	181.8	67.5	25.8	174.0	71.4
October	29.8	145.5	75.0	25.6	32.4	58.6	24.8	38.5	60.4
Year 2 (1997)									
June	28.6	100.1	79.0	25.3	150.3	60.4	26.5	160.8	62.9
July	29.0	188.3	83.2	26.2	265.9	65.6	25.8	311.4	68.2
August	29.2	130.7	76.1	24.0	302.8	73.9	24.3	146.6	56.5
September	30.3	298.3	84.6	24.6	175.9	66.6	25.2	150.1	62.3
October	28.9	150.4	77.2	26.1	39.3	56.8	24.6	88.7	60.9

*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

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

Table 3: Mean protein contents(%) of six soyabean genotypes sown in three locations in 1996 and 1997

Genotype	Mokwa	Jos	Zaria	Mean
Bossier	40.33c	41.47a	41.70a	41.17a
TGm 737p	39.00d	39.13d	37.92e	38.68b
TGx 536-02D	40.78b	36.77f	38.93d	38.83b
TGx 849-313D	42.00a	40.55b	40.83c	41.13a
TGx 923-2E	40.47b	39.90c	41.37b	40.58a
TGx 1448-2E	38.78d	38.03e	40.58c	39.13b
Mean	40.23a	39.31b	40.22a	

	Year 1	Year 2	Mean
Bossier	41.34a	40.99a	41.17a
TGm 737p	38.24cd	39.12b	38.68b
TGx 536-02D	37 63d	40.02ab	38.83b
TGx 849-313D	40.85ab	41.40a	41.13a
TGx 923-2E	40.09ab	41.07a	40.58a
TGx 1448-2E	39 13bc	39.13b	39.13b
Mean	39.54a	40.29a	

Location	Year 1	Year 2	Mean
Mokwa	39.52a	40.94a	40.23a
Jos	39.17a	39.44a	39.31b
Zaria	39.96a	40.48a	40.22a
Mean	39.55a	40.29a	

Means with similar alphabets along the column and row are not significantly different at probability of 0.05

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 TGx923-2E

Table 4: Mean oil content(%) of six soyabean genotypes sown in three locations in 1996 and 1997

Genotype	Mokwa	Jos	Zaria	Mean
Bossier	18.35b	20.33a	17.92d	18.87ab
TGm 737p	18.13bc	20.33a	18.98c	18.05b
TGx 536-02D	19.02a	17.03c	19.30a	19.60a
TGx 849-313D	17.73c	20.48a	19.00a	18.33b
TGx 923-2E	18.33b	18.27b	18.82c	18.44ab
TGx 1448-2E	19.12a	18.17b	19.18ac	19.04ab
Mean	18.45a	18.82a	18.87a	
	Year 1	Year 2	Mean	
Bossier	19.47a	18.27a	18.87ab	
TGm 737p	17.88a	18.22a	18.05b	
TGx 536-02D	19.67a	19.53a	19.60a	
TGx 849-313D	18.53a	18.13a	18.33b	
TGx 923-2E	18.59a	18.29a	18.44ab	
TGx 1448-2E	18.87a	19.21a	19.04ab	
Mean	18.84a	18.61a		
Location	Year 1	Year 2	Mean	
Mokwa	18.77a	18.12a	18.45a	
Jos	18.88a	18.82a	18.85a	
Zaria	18.84a	18.89a	18.87a	
Mean	18.83a	18.61a		

Means with similar alphabets along column and row are not significantly different at probability of 0.05

(19.04%) 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.

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

		Oil content (%)		
		Year 1 (1996)	**Year 2 (1997)**	**n = 12**
Protein (%)	Jos	-0.443 ns	0.675 *	
	Zaria	-0.563 ns	0.223 ns	
	Mokwa	-0.381 ns	-0.846**	

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

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