Evaluation of Growth Habit and Yield Characteristics Heritability in Three Line Cultivars of *Sphenostylis sternocarpa* and Two Line Cultivars of *Sphenostylis schwenfurthii*

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ABSTRACT: Purified cultivars of three varietal lines of *Sphenostylis sternocarpa* and two varietal lines of *Sphenostylis schwenfurthii* were subjected to ten diallel crosses. The growth habits and yield characteristics of the parental lines and the hybrids (F_2 & F_3) were evaluated. Heritability estimates of the characters in F_2 and F_3 were calculated. The parental lines were similar except for a few characters and the F_2 and F_3 hybrids showed significant variations in the heritability estimates of the growth and yield characteristics. The determinate and indeterminate growth habits showed a 3:1 model of segregation in F_2, while climbing ability showed a 9:7 segregation ratio in the F_2. No genetic linkage between the growth habit genes and the genes controlling yield characters was detected.

INTRODUCTION

The African Yam beans (Sphenostylis), is a complex group belonging to the Family Fabaceae. The group is typified by the genera/species *Sphenostylis sternocarpa* Hochst. Members of the group are predominantly herbaceous and produce pea-like flowers and give rise to pods with four to ten seeds [1]. *Sphenostylis schwenfurthii* is a very close relative to the type species *S. sternocarpa*. Morphologically, *S. sternocarpa* and *S. schwenfurthii* are very similar. The major differences between the two are mainly established in the predominant flower colour, pod shape and seed shape and colour, pod shape and seed shape and colour. The variations in these characters are presented in Table 1.

Table 1 (a) : The charater variations in the species of Sphenostylis studied.

(i) *Sphenostylis sternocarp:* Pkflower, blace spherical seeds, long curve pods.
(ii) *S phenostylis sternocarpa:* Purple flower, b rown s pherical s eeds, l ong c urve pods.
(iii) *Sphenostylis sternocarpa:* Purple flower, black speckle heart sharp seeds, long curve pods.
(iv) *Sphenostylis schwenfurthii:* Light green flower, black kidney shaped seeds, shark straight pods.
(v) *Sphenostylis schwenfurthii:*Light green flower, Cream spherical seed, short straight pods.

(b): Characters used in the evaluation
1. Growth habit
2. Guide length
3. Climbing habit

4. Number of nodes (at maturity)
5. Plant height (at maturity/beginning of flowering)
6. Seed set (seeds per pod)
7. Number of pods per plant
8. Seed size (100 seed weight)
9. Maturity date (No of days to maturity)

Several uses have been recommended for members of the group. These include, its use as a highly proteinous food [2], [1], [3] and treatment of drunkenness and other diseases [4].
Growth habits inheritance in beans, has been well studied (Leakey, 1988). Linkage or pleiotropic effects of genes controlling growth habits with other morphological traits have also been studied (Leakey, 1988).
The evaluation of the phenological and physiological traits of beans has similarly been studied (Scully and Wallace, 1990).
The preference for certain bean types are base on agronomic and consumer character as well as yield. The consumer characters include the organolyptic properties and preparation strategies.
The primary objective in these studies was to analyze the genic combinations affecting growth habits and yield parameters.

MATERIALS AND METHODS

Three varietal lines of *S. sternocarpa* and two of *S. schwenfurthii* were collected from the local market and primarily cultivated to ascertain the purity of the lines. The varietal lines were identified based on the character description presented in Table I (a). The lines were advanced by two generations to confirm the consistency of the lines. Seeds were also separated into, seed size classes - large (>40g/100 seeds) medium, ≏ 35g/100 seed and < 25g/100 seeds).
The lines were well adapted to the farm environmental conditions at the commercial/experimental farm of University of Uyo.
The parental lines were crossed in a diallel mating design with reciprocals to produce the F_1 hybrids.
The F_1 seeds of each cross (including the reciprocals) were subsequently planted in the field to produce F_2 seeds and F_3.
The F_2 seeds were planted in 5 randomized complete blocks, along side the parental liens in the fields. The blocks consisted of five rows of 8m long with 0.2m between plants and 0.7m between rows. The plants were watered regularly and standard agronomic practise adapted against weeds and insect pest. The F_2 seeds were similarly advanced to F_3 generation. The plants were evaluated in plots and lines using the characteristics presented in Table 1b.

EVALUATION OF PARENTAL, F_2 AND F_3 LINES

Five plants of each parental line were evaluated for the eight characteristics in Table II. Similarly, five plants of the F_2 and the F_3 were evaluated.

Statistical Analysis

Statistical Analysis used in the study include Analysis of Variance. This was done only on the mean parental data (Table 2). The F_2 and F_3 diallel cross were analysed using the model of Griffing (model 1) (Griffing, 1959). The square test was used to determine the linkage effects between genes controlling size of seeds and growth habits. This test also expressed the frequencies of segregation in F_2 and F_3 generations of medium to large seeded individuals. Parent- offspring heritability estimates were calculated using regression of the F_3 mean value and the F_2 individual data (Table 7). This method was based on the model of Smith and Kinman (1965).
Correlation analysis was also done for some major characteristics including plant height and nodes per plant.

RESULTS

PARENTAL EVALUATIONS

Character evaluations of the parental lines were generally consistent excepts for plant height, nodes per main stem and seed set per pod (Table 2). The parental lines were also similar in all characteristics studied, except for the plant height and nodes per stem.
There was a very strong correlation between the plant height and nodes per stem in all the lines evaluated. However there was a significant variation in characteristics evaluated between the parental lines and the F_2 and F_3 hybrids.
The guide lengths in the (5) parental lines were also slightly different (Table 2). The parent IV and V had longer guide, slightly greater plants height and larger seeds than the other three parents (I, II & III). The other parental lines had smaller seeds and larger number of seeds per plant (Table 2). The number of pods per plant was also positively correlated to the number of nodes per plant (Table 2). The cross between I and IV and II & III produced progenies with smaller seed but higher seed numbers per pod and also higher pod number per plant than the parents (Table 3). The last observation is expected, because of the high positive correlation between the height of plant and the number of nodes and number of pods per plant.

Combining Ability Analysis (CAA) of F_2 & F_3 Population

The F_2 and F_3 generation showed significant variation for all the characteristics evaluated (Table 4). Two types of combining abilities were observed. The general combining ability (GCA) of the parental lines was the source of variation among the genotypes. The specific combining ability (SCA) was not very significant for the characters evaluated. However significant variance was notice with number of nodes on main stem in the F_2 and number of seeds per plant in F_3 (Table 5). The significance of GCA for traits in legume beans has been reported in other studies (Niehius & Singh 1988). All five parental lines had signifant positive estimates of GCA when crossed among themselves. The progenies also tended to inherit the characteristics of taller plants and late maturity.

The two growth habits evaluated (indeterminated and determinate growth habits) followed the 3:1 model of segregation in the F_2. Similarly there was greater number of small to large or medium seeded segragants with indeterminate growth habits in the F_2 generations of most crosses.

Segregation frequencies were normal in the F_2 generation without linkage or irregular segregation ratios (Table 6). The climbing ability trait showed a possible two dominant gene node of inherentance with a 9:7 segregation ratio in the F_2

Heritability estimates (Table 7), for all the characters studies were low in all the crosses. This suggests that the parental lines used in the crosses have a common genetic background. The Chi-sqare values (Table 6) strongly support this deduction. These results are generally in agreement with results of Niehuis and Singh, (1988) and those of Singh (1991). These result suggest that the genetic differences among the different varieties of *Sphenostylis* may be too divergent and when crossed, a disruption in genic balance occurs. Genetic incompatability in the crosses may be expressed in terms of hybrid depression or cripples.

DISCUSSION

The result obtained in this study vividly showed that most of the genotypic variance was due to general combining ability (GCA) and the GCA reaction is due mainly to additive genetic effects. This impression is supported by the segregation of growth habit characters in F_2 and F_3 progenies of the diallel crosses.

The mode of inheritance appeared to be primarily the inheritance of simple dominant/recessive genes. Most of the characters were controlled by single genes except the gene for the climbing habit, which appeared to be inherited as a two dominant genes factor. All the parental lines showed an increased GCA effect on all growth characters; guide length, node number, plant height and climbing ability. The observation seems to be due to the gene pool which is dominated by single character major genes. The behaviour of the growth habit is significant, following from the direct relationship between growth habits and crop yield. Indeed increasing yield potential of common beans through growth habit modifications is a valid breeding objective and also a major strategy used to increased yield (White *et al.*, 1992).

The relevance of improved growth habit to yield could be because yield is dependent on growth structures, through genic recombinations that improved yield through controlling physiological pathways (White & Izquiedo,1991) or by merely changing the growth habit to a more productive, but different plant constitution.

Seed size showed moderate inheritance in the crosses involving the large seeded parents. No linkage effects with growth habits were observed excepst for the reduction in seed size following an increase in seed number

per pod. It will be determined subsequently if significant genic differences exist with the germplasm of sphenostylis genera/varieties and whether desirable genes from variety can readily be transferred to another in simple intra-gene pool crosses without altering important traits.

Table 2: Mean Evaluation of Growth Habit and Yield Characteristic of Five Parental Lines of *S. sternocarpa/S. schwenfurthii*

Parental line	Seed 100 Seed Weight	Growth Habit	Guide Length (0-3)	Climbing Ability (0-10)	No. of Nodes on Stem	Plant Height at Maturity (cm)	Maturity Date	Speed Set Per Pod	Pod Number Pere Plant
I I	16.8g	A	0.5	2.0	10.6	43.3	71.3	8.3*	18.8
II II	10.2g	B	1.6	3.6	10.4	41.2	72.4	9.1*	18.0
III III	20.5g	A	0.1	1.9	11.5	62.1	78.1	7.0	19.7
IV IV	30.8g	C	3.0	6.6	15.8*	81.5*	82.7	6.1	20.8
V V	36.4g	D	2.1	8.3	23.1*	156.3*	88.5	6.5	22.5*

Means were tested for significance at P = 0.05 level using the Dumcan's Multiple Range Test

* Indicates significant values.

Table 3: Mean Evaluation of Growth Habit and h Yield Characteristic of the diallel Crosses of Among the Five Parental Lines of *S. sternocarpa/S. schwenfurthii*

Crosses	Guide Length (0-3)	Climbing Ability (0-10)	No. of Nodes on Stem	Plant Height at Maturity (cm)	Maturity Date	Speed Set Per Pod	Pod Number Pere Plant	Seed Size (100 Seed Weight) (gm)
I x I	0.60	1.1	16.1	78.9	81.0	5.0	26.3	16.1
I x III	0.80	1.1	15.5	69.7	79.9	5.7	25.1	15.3
I x IV	1.00	1.4	10.9	42.1*	69.8	9.5*	18.9	10.7
I x IV	1.09	1.9	12.7	58.3	80.4*	5.5	26.7*	18.3
II xIII	1.27	6.4	9.8	48.1*	71.2	8.9	19.2	10.5
II x IV	1.45	6.9	16.7	60.2	81.7*	6.2	22.7	20.7*
II x V	2.15*	5.3*	11.5	67.9	83.3*	6.1	21.8	19.3
III x IV	2.90*	8.9*	17.3*	70.7	79.4	5.3	25.7*	19.7
IV x V	1.99	7.2*	27.2*	181.0*	88.1*	5.1	26.7*	18.6*
III x V	1.43	9.0*	26.1*	77.3*	85.6*	5.6	25.6*	20.1*

Means were evaluated at P = 0.05 confidence level using the Dumcan's Multiple Range Test. Asterics indicate signigicant values.

Table 4: Mean Squares of Dialled Analyses for the Eight Characters of F_2 and F_3 Progeny

Source of Variation	df		Guide Length		Climbing Ability		No. of Nodes		Plant Height		Maturity		No. of Seeds Per Pod		No. of Pods Per Plant		100 Seeds Weight	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
Genotype	9	9	2.52	2.00	13.18	8.34	16.98	18.16	3796.5	2073.3	61.19	11.50	2095.1	2598.6	211.5	256.8	163.55	57.64
GCA	4	4	4.81	4.30	27.50	18.00	36.31	39.73	7998.2	4045.6	9.15	16.71	4986.5	5139.6	459.2	499.7	257.31	178.23
SCA	5	5	0.29	0.09	1.01	0.69	1.01	2.51	490.7	248.7	3.55	6.91	351.8	275.3	38.6	27.7	12.74	9.79
Error	18	9	0.02	0.02	0.07	0.14	0.55	0.22	80.7	42.7	1.24	0.97	80.7	140.6	9.2	10.8	1.98	1.35
C V(%)	-		9.42	8.28	9.45	13,33	5.02	3.04	10.01	6.98	1.53	1.26	13.06	12.99	12.66	13.13	4.30	4.26

Estimates were analysed at P = 0.05 level.

Table 5: Effect of General Combining Ability of Growth Habit and Yield Characters of F_2 and F_3 Diallel Analyses

Source Parental Lines	Guide Length		Climbing Ability		No. of Nodes		Plant Height		Maturity Date		No. of Seeds Per Pod		No. of Pods Per Plant		100 Seeds Weight	
	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3	F_2	F_3
1	-0.58	-0.79	-1.25	-1.68	-1.99	-1.98	-20.1	-19.9	0.52	0.51	-6.21	-7.97	23.5	-28.8	5.20	4.90
2	-0.55	-0.73	-1.20	-1.05	-1.20	-2.16	-18.3	-20.7	0.31	0.02	-5.91	-6.77	21.3	-33.3	5.55	4.61
3	-0.02	-0.04	+0.45	+0.26	-1.11	+0.51*	5.93	-3.00	-1.53	-2.23	+7.35	-8.13*	32.1*	-34.5*	9.09	8.11
4	+0.03	+0.32	-0.40	+0.28*	+0.42	+0.28*	0.91	-0.83	0.38	-0.75	8.90*	10.68*	11.5*	19.5*	-2.08	-1.48
5	+1.15	+1.16	+2.9	+2.67	+0.97	+0.61*	39.1	36.7	1.02	2.41	11.41*	10.10*	16.8*	14.3*	+1.30	+0.62

*Significant at P = 0.05.

Table 6: Chi-Square (χ^2) Tests of Individual F_2 and F_3 Plant with Seed Size and Growth Habit and Segregation Frequencies.

Crosses	Growth Habit	Seed Sizes															
		Small				Medium				Large				Bulk (all seed sizes)			
		F_2		F_3		F_2		F_3		F_2		F_3		F_2		F_3	
		No	χ^2 (3:1)	No	χ^2 (5:3)	No	χ^2 (3:1)	No	χ^2 (5:3)	No	χ^2 (3:1)	No	χ^2 (5:3)	No	χ^2 (3:1)	No	χ^2 (5:3)
I x II	Small	2	0.70	2	0.43	3	1.33	26	6.11	11	1.43	3	6.23	41	0.31	59	0.40
I x III	Medium	2	0.63	3	0.97	1	1.29	17	4.19	9	11.91	10	1.84	57	1.19	60	1.16
I x IV	Medium	4	10.11*	18	5.79	9	5.75	5	7.75	25	9.25	7	6.10	39	7.25	71	1.13
II x III	Small	6	9.12*	10	7.17	11	0.00	23	2.64	23	3.25	7	5.19	48	2.37	32	5.41
II x IV	Large	14	7.29*	5	3.57	11	6.45	6	2.99	15	5.15	7	5.14	46	1.57	28	2.51
III x IV	Large	14	2.51	5	0.22	10	5.21	6	8.37	3	0.00	21	11.50	59	10.6	55	0.09
I x V	Small	5	4.64	11	2.59	25	9.27	14	4.81	1	0.00	0	14.50	63	1.14	20	0.22
II x V	Large	21	6.40	16	0.48	6	2.12	27	0.19	0	3.70	8	1.16	44	2.77	68	0.58
III x V	Large	28	0.57	20	4.40	1	0.19	30	0.13	0	2.70	5	2.28	61	3.14	70	0.23
IV x V	Large	7	0.00	29	1.57	3	0.31	7	0.00	8	2.34	35	0.70	50	0.34	56	8.29

*Significant at P = 0.05.

Table 7: Parent – Offspring Heritabiltiy Estimates of Growth Habit and Yield Characters

Crosses	Heritability							
	Guide	Climbing Ability	No. of Nodes on Stem	Plant Height at Maturity	Maturity Date	Seeds Set Per Pod	Pods No. Per Plant	Seed Size (100 Seed Weight)
I x II	0.36	0.28	0.58	0.22	0.26	0.17	0.50	0.30
I x III	0.65	0.28	0.51	0.30	0.37	0.15	0.27	0.39
I x IV	0.48	0.21	0.30	0.37	0.09	0.32	0.33	0.16
I x V	0.21	0.33	0.50	0.54	0.09	0.40	0.61	0.21
II x III	0.21	0.17	0.55	0.41	0.17	0.19	0.45	0.28
II x IV	0.39	0.09	0.24	0.22	0.10	0.12	0.51	0.19
II x V	0.16	0.32	0.25	0.33	0.13	0.42	0.29	0.18
III x IV	0.60	0.55	0.43	0.28	0.15	0.28	0.27	0.24
IV x V	0.29	0.42	0.42	0.16	0.24	0.15	0.18	0.14

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