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Correlated Studies between Growth and Yield Characters of Castor Bean (*Ricinus communis L.*)

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Abstract- A field study was conducted at the Teaching and Research Farm, University of Agriculture, Makurdi, Nigeria in 2008 and 2009 cropping seasons. The objectives were to identify important determiners of yield characters and to determine the correlations between growth characters viz: number of leaves per plant, length of internodes per plant, number of internodes per plant, leaf area index, net assimilation rate, absolute growth rate, plant height; and yield characters namely: panicles per plant, capsules per plant, capsules per panicle, seeds per plant, dry weight of harvestable material, total dry weight per plant, harvest index, seed yield, 100 seed weight and oil yield at 4, 8, 12, 16, 20, 24 and 28 weeks after sowing(WAS). The technique of growth analysis described by Steel and Torrie was adopted for data collection. Growth characters were correlated with yield characters and correlation coefficients were determined. Results showed that, there were positive and significant correlations between number of leaves and all the yield characters at 8 to 28 WAS except capsules per plant; number of internodes and yield characters at 4, 20 and 24 WAS; length of internodes and yield characters at 4 to 28 WAS, except capsules per panicle at 4, 8, 28 WAS, seed yield and 100 seed weight at 4 and 8 WAS, oil yield at 4 WAS. Leaf area index correlated positively and significantly with yield characters at 8 to 28 WAS, except capsules per panicle at 8 and 28 WAS; net assimilation rate with yield characters except capsules per panicle at 24 and 28 WAS, dry weight of harvestable material, harvest index and 100 seed weight at 4 and 8 WAS. Correlations between absolute growth rate and all the yield characters were highly significant and positive except panicle per plant at 8 WAS. There were positive correlations between plant height and all the yield characters at 8 to 28 WAS, which were significant. Each growth character that correlated positively and significantly with a yield character indicates that it is an important determiner of that yield character.

Index Terms- Castor bean, correlated studies, growth characters, yield characters

I. INTRODUCTION

Castor bean (*Ricinus communis* L.) a member of the family Euphorbiaceae is indigenous to Africa (Voss, 1996) and India (Baskin et al, 2000).It is an industrial crop grown for economic seeds exploited mainly for producing oil (Uvah,1991). Growth, development and yield of crop plants, together with factors affecting them, occupy a position of primary importance in crop production. Growth and yield are physiologically interrelated or correlated (Hudson, 1984). Generally, growth is an irreversible increase in size (increase in dry weight, length or diameter – Nothman, 2001) with quantitative attributes while yield is the net photosynthetic produce and has quantitative attributes also.

Hudson (1984) reported that growth and yield of crops are products of interplay or correlation between its genetic constitution and the environment. While the genetic make up of a crop is a fixed entity that delimits the extent to which that crop can develop and yield, the actual performance of the crop is regulated by the environment in which it grows.

Proper identification of important determiners of yield (growth characters) in crop plants is a step towards increasing crop yield throuth manipulation of growth characters by application of growth regulators (Chen,2001). Mukaila et al. (2005) suggested that in order to obtain a precise knowledge of the factors limiting growth and yield of crops in West Africa, quantitative and correlative analysis of growth and yield of field crops should be made. Variation in weather conditions significantly influenced net assimilation rate, relative growth rate, leaf area and dry matter accumulation of cowpea seedlings in Southern Nigeria (Ezedinma,1967).

Arkley and Ulrich (1962) reported that of the three factors on which plant growth depends namely; soil, climate and cultural practices, the effect of climate is the most complex. Generally, the degree of association (correlation) between growth and yield characters of crops depends on climatic and genetic factors (Davis,1978).

In order to obtain a precise knowledge on important determiners of yield of crops, Singh and Chaudhary (1979) suggested that various growth and yield characters be correlated to assert their degree of association. There is dearth of information on correlated studies with respect to growth and yield characters of castor bean. The objective of this study was therefore, to determine the growth characters which are important determiners of yield through correlated studies between growth and yield characters of castor bean.

II. MATERIALS AND METHODS

Four castor bean accessions viz: LAF-4, LAF-11, AKW-5, AKW-7 were used as treatments. Three castor bean seeds were sown per hill on the ridge and spaced 90cm x 50cm with a population density of 22, 222 plants per hectare. Thinning to one seedling per stand was done three weeks after sowing (WAS). The experiment was laid out in Randomized Complete Block Design with three replications. The gross plot size was 8m x 9.9m (79.2m^2) with net plot size of 7.2m^2.

The plots were weeded manually twice, before and after flowering at 30 and 60 days intervals respectively. Basal application of NPK fertilizer (20:10:10) at the rate of 100kgN/ha was done at 40 days after sowing. The plants were sprayed fortnightly with Vetox 85 insecticide at the rate of 1.1kg chemical per 225 litres of water starting from 9 WAS to minimize insect damage by weevils, leaf rollers, grasshoppers and aphids. Growth and yield characters were correlated at 4 to 8WAS to assert their degree of association.

Data on selected growth and yield characters collected from five randomly labelled plants from net plots were recorded at 4, 8, 12, 16, 20, 24 and 28 weeks after sowing and included the following:

Growth Characters:

(i) Number of leaves per plant
(ii) Length of internodes per plant (cm)
(iii) Number of internodes per plant
(iv) Leaf Area Index (LAI) = $\frac{LA}{GA}$

where:

LA = total leaf area in cm^2.
GA = area covered on ground in cm^2.

(v) Net Assimilation Rate (NAR) =
$\frac{W_2 - W_1}{A_2 - A_1} \times \frac{\log A_2 - \log A_1}{t_2 - t_1}$ $g/m^2/day$

where:

W_1 and W_2 = total dry weight of plant material (g).

A_2-A_1 = total leaf area (cm^2)
t_1 and t_2 = sampling times (weeks after sowing)

(vi) Absolute Growth Rate (AGR) =
$\frac{W_2 - W_1}{t_2 - t_1}$ $g/m^2/day$

where:

W_1, W_2 = total dry weight of plant material (g)
A_1, A_2 = total leaf area (cm^2)
t_1, t_2 = sampling times (weeks after sowing).

(vii) Plant height (cm)

Yield Characters:

(i) Panicles per plant
(ii) Capsules per plant
(iii) Capsules per panicle
(iv) Seeds per plant
(v)Dry weight of harvestable material (g)
(vi) Total dry weight per plant (g)
(vii) Harvest index (HI) = $\frac{Wm}{W}$

where:

Wm = dry weight of marketable material (g)
W = total dry weight of plant material (g)

(viii) Seed yield (kg/ha)
(ix) 100 seed weight (g)
(x) Oil yield (%)

The technique of growth analysis was adopted according to Hunt (1978), and Steel and Torrie (1980).

Statistical Analysis:

All growth characters were correlated with yield characters according to Singh and Chaudhary (1979) at 4, 8, 12, 16, 20, 24 and 28 weeks after sowing to assert their degree of association. GenStat was used.

III. RESULTS

Number of Leaves per Plant

Data on correlation coefficients of number of leaves and yield characters are presented in Table 1. There were positive and highly significant correlations between number of leaves and all the yield characters of castor bean at 8 to 28 WAS, except correlations between number of leaves and capsules per plant which were positive but not significant. Number of leaves was an important determiner of the yield characters evaluated at 8 to 28WAS.

Length of Internodes per Plant

Correlation coefficients of length of internodes per plant and yield characters are summarized in Table 2. Positive and highly significant correlations were obtained between length of internodes and panicles per plant at 4 to 28 WAS; length of internodes and capsules per plant at 4 WAS to 24 WAS; length of internodes and capsules per panicle at 20 and 24 WAS; length of internodes and seeds per plant at 4 to 24 WAS; length of internodes and dry weight of harvestable material at 4 to 28 WAS. Correlations between length of internodes and total dry weight per plant at 12 to 24 WAS; length of internodes and harvest index at 4 to 28 WAS; length of internodes and seed yield at 12 to 28 WAS; length of internodes and 100 seed weight at 12 to 24 WAS; length of internodes and oil yield at 12 to 28 WAS were also positive and highly significant. Therefore, length of internodes importantly determined yield characters at these growth stages.

Number of Internodes per Plant

Table 3 shows that correlations between number of internodes and panicles per plant at 4, 20 and 24 WAS, were positive and highly significant. At 20 and 28 WAS, positive and highly significant correlations between number of internodes and capsules per plant were observed. Number of internodes positively and significantly correlated with capsules per panicle, seeds per plant, dry weight of harvestable material, total dry weight per plant, harvest index and 100 seed weight at 4, 20 and 24 WAS. Correlations between number of internodes and seed yield at 4 and 20 WAS; number of internodes and oil yield at 4 WAS were also positive and highly significant. Number of

internodes was an important determiner of yield characters at 4, 20 and 24WAS.

Leaf Area Index

Results on correlations between leaf area index (LAI) and yield characters are presented in Table 4. Correlations between leaf area index and other yield characters at 8 to 28 WAS were positive and highly significant, except correlations between leaf area index and capsules per plant at 8, 12 and 28 WAS; leaf area index and total dry weight per plant at 8 and 28 WAS; leaf area index and 100 seed weight at 12 and 28 WAS which were positive and significant. This implies that leaf area index importantly determined the yield characters it positively and significantly correlated.

Net Assimilation Rate

Table 5 presents results of correlations between net assimilation rate and yield characters. Net assimilation rate was positively correlated with panicles per plant at 4 to 28 WAS; capsules per plant at 12 to 28 WAS; seeds per plant at 4 to 28 WAS except at 8 WAS; dry weight of harvestable material at 12 to 28 WAS; total dry weight per plant at 8 to 28 WAS and these correlations were highly significant.

Harvest index and seed yield were positively correlated with net assimilation rate at 12 to 28 WAS which were also highly significant. Correlations between 100 seed weight and net assimilation rate at 12 to 20 WAS; oil yield and net assimilation rate at 4 to 16 WAS produced positive and highly significant results. These results showed that, net assimilation rate was also an important determiner of yield characters of castor bean.

Absolute Growth Rate

Correlation results between absolute growth rate (AGR) and yield characters are summarized in Table 6. Correlations between capsules per plant, seeds per plant, dry weight of harvestable material, total dry weight per plant, harvest index, seed yield, 100 seed weight and absolute growth rate at 4 to 28 WAS were positive and highly significant. At 8 WAS, capsules per panicle did not significantly correlate with absolute growth rate. Oil yield positively correlated with absolute growth rate at 4 to 28 WAS and these correlations were highly significant except at 24 WAS. Thus, absolute growth rate determined the yield characters evaluated in this study.

Plant Height

Table 7 shows correlation coefficients for correlations between plant height and yield characters. There were positive and highly significant correlations between plant height and all the yield characters at most of the growth stages between 4 and 28 WAS. Correlations between capsules per panicle, oil yield and plant height at 28 WAS were not significant, but positive. These results proved plant height to be an important determiner of the yield character.

IV. DISCUSSION

Growth, development and yield of crop plants, together with factors affecting them, occupy a position of primary importance in crop production. Growth and yield are physiologically correlated. Growth characters are functions of dry weight increase or dry matter production per unit time. The dry matter produced (assimilates) were translocated and partitioned to various plant organs (yield characters).The physiological interrelationship or association between growth and yield is evident in the highly positive correlations observed between growth characters and yield characters in this study. Generally, growth according to Hunt (1978) is an irreversible increase in size with quantitative attributes while yield is the net photosynthetic produce or the dry weight of the end product of growth and development and also has quantitative attributes.

Hudson (1984) reported that growth, development and yield of crops are products of interplay between its genetic constitution and the environment. While the genetic make up of a crop is a fixed entity that delimits the extent to which that crop can develop and yield, the actual performance of the crop is regulated by the environment in which it grows.

V. CONCLUSION

Generally, correlation takes place between two types of variables viz: dependent and fixed. Yield of crops depends on the nature and magnitude of growth that has been made. Growth characters are fixed variables while yield characters are dependent variables. The positive nature of these correlations indicates that any decrease or increase in the growth made will translate into proportional decrease or increase in the yield.

Based on results of this study, the selected growth characters correlated positively with yield characters at 4 to 28 WAS, and these correlations were highly significant. This implies that there was high degree of association between the growth and yield characters evaluated. All the growth characters evaluated were therefore important determiners of the yield characters which they positively correlated in this study.

Table 1: Correlations Between Number of Leaves Per Plant and Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008 (Combined Data).

	Weeks After Sowing					
Treatments	**Week 8**	**Week 12**	**Week 16**	**Week 20**	**Week 24**	**Week 28**
Panicle per plant	.418**	.554**	.551**	.560**	.571**	.592**
Capsules per plant	.146	.335**	.326**	.352**	.364**	.396**
Capsules per panicle	.530**	.489**	.501**	.498**	.590**	.485*
Seeds per plant	.179**	.365**	.357**	.383**	.395**	.420**
Dry weight of harvestable material	.337**	.386**	.406**	.399**	.400**	.417**
Total dry weight per plant	.459**	.444**	.460**	.455**	.456**	.446**
Harvest Index	.280**	.345**	.362**	.366**	.364**	.388**
Seed yield	.257**	.356**	.349**	.346**	.345**	.367**
100 seed weight	.376**	.401**	.403**	.408**	.371**	.377**
Oil yield	.582**	.554**	.536**	.539**	.536**	.538**

* Significant at P = 0.05

** Significant at P = 0.01

Table2. Correlations Between Length of Internodes Per Plant and Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008 (Combined Data).

	Weeks After Sowing						
Treatments	Week_4	Week_8	Week_12	Week_16	Week_20	Week_24	Week_28
Panicle per plant	.534**	.522**	.599**	.657**	.688**	.721**	.499**
Capsules per plant	.661**	.661**	.644**	.629**	.402**	.598**	.263*
Capsules per panicle	.041	.099	.236*	.298*	.289**	.425**	.170
Seeds per plant	.681**	.683**	.669**	.641**	.414**	.618**	.277*
Dry weight of harvestable Material	.396**	.387**	.574**	.722**	.590**	.704**	.347**
Total dry weight per plant	.275*	.278*	.462**	.604**	.523**	.621**	.262*
Harvest Index	.373**	.360**	.555**	.700**	.582**	.682**	.364**
Seed Yield	.225	.222	.405**	.589**	.559**	.659**	.361**
100 Seed weight	.012	.027	.304**	.426**	.474**	.442**	.302*
Oil Yield	.204	.247*	.335**	.288**	.505**	.421**	.457**

* Significant at P = 0.05
** Significant at P = 0.0

Table 3. Correlations Between Number of Internodes Per Plant and Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008(Combined Data).

	Weeks After Sowing						
Treatments	**Week_4**	**Week_8**	**Week_12**	**Week_16**	**Week_20**	**Week_24**	**Week_28**
Panicle per plant	.335**	.055	.125	.158	.398**	.351**	.234*
Capsules per plant	.421**	.259**	.241*	.158	.346**	.251**	.128
Capsules per panicle	.162**	.264*	.254*	.181	.370**	.347**	.185
Seeds per plant	.425**	.261*	.264*	.198	.361**	.284**	.155
Dry weight of harvestable material	.552**	.017*	.075	.090	.379**	.175**	.023
Total dry weight per plant	.358**	.033	.041	.052	.357**	.203**	.040
Harvest index	.514**	.048	.023	.064	.353**	.158**	.008
Seed yield	.429**	.000	.032	.051	.396**	.302*	.173
100 seed weight	.223**	.045	.063*	.100	.307**	.315**	.222
Oil yield	.061**	.079	.071	.052	.040	.169	.239*

* Significant at P = 0.05
** Significant at P = 0.01

Table 4. Correlations Between Leaf Area Index Per Plant And Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008 (Combined Data).

	Weeks After Sowing					
Treatments	**Week_8**	**Week_12**	**Week_16**	**Week_20**	**Week_24**	**Week_28**
Panicle per plant	.528**	.739**	.634**	.675**	.650**	.447**
Capsules per plant	.327**	.507**	.326**	.555**	.548**	.508**
Capsules per panicle	.225	.182*	.449**	.339**	.151**	.230
Seeds per plant	.333**	.509**	.353**	.584**	.575**	.535**
Dry weight of harvestable Material	.485**	.602**	.616**	.751**	.478**	.480**
Total dry weight per plant	.392*	.431**	.685**	.632**	.304**	.327*
Harvest index	.482**	.590**	.575**	.721**	.492**	.476**
Seed yield	.571**	.590**	.449**	.582**	.458**	.372**
100 seed weight	.347**	.157	.334**	.375**	.113**	.197*
Oil yield	.421**	.447**	.313**	.389**	.413**	.421**

* Significant at P = 0.05
** Significant at P = 0.01

Table 5. Correlations Between Net Assimilation Rate (G/M^2/Day) Per Plant and Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008(Combined Data).

	Weeks After Sowing						
Treatments	**Week _4**	**Week _8**	**Week _12**	**Week _16**	**Week _20**	**Week _24**	**Week _28**
Panicle per plant	.520**	.389**	.735**	.594**	.467**	.466**	.403**
Capsules per plant	.255*	.175	.561**	.380**	.470**	.644**	.311**
Capsules per panicle	.270*	.287*	.245*	.252*	.176	.001	.210
Seeds per plant	.256**	.176	.568**	.389**	.489**	.646**	.350**
Dry weight of harvestable Material	.100	.073	.616**	.415**	.486**	.512**	.373**
Total dry weight per plant	.064	.050**	.468**	.319**	.355**	.332**	.279*
Harvest Index	.078	.053	.606**	.399**	.455**	.480**	.379**
Seed Yield	.295*	.301*	.559**	.465**	.463**	.487**	.387**
100 Seed weight	.171	.079	.316**	.314**	.390**	.203	.292*
Oil Yield	.515**	.552**	.462**	.589**	.215	.136	.215

* Significant at P = 0.05
** Significant at P = 0.01

Table 6. Correlations Between Absolute Growth Rate (G/M^2/Day) Per Plant and Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008 (Combined Data).

	Weeks After Sowing						
Treatments	**Week_4**	**Week_8**	**Week_12**	**Week_16**	**Week_20**	**Week_24**	**Week_28**
Panicle per plant	.276*	.156	.413**	.440**	.340**	.304**	.373**
Capsules per plant	.428**	.321**	.522**	.555**	.408**	.449**	.431**
Capsules per panicle	.270*	.162	.303**	.293*	.296*	.345**	.337**
Seeds per Plant	.423**	.316**	.514**	.548**	.405**	.441**	.418**
Dry weight of harvestable Material	.548**	.372**	.602**	.633**	.511**	.446**	.398**
Total dry weight per plant	.649**	.457**	.683**	.837**	.636**	.553**	.586**
Harvest Index	.480**	.322**	.521**	.524**	.430**	.374**	.309**
Seed Yield	.709**	.548**	.665**	.748**	.514**	.478**	.514**
100 Seed weight	.816**	.710**	.672**	.615**	.522**	.526	.637**
Oil Yield	.345**	.373**	.418**	.358**	.354**	.304	.389**

* Significant at P = 0.05
** Significant at P = 0.01

Table 7. Correlations Between Plant Height (Cm) and Yield Characters of Castor Bean at Different Times of Sampling in 2006 and 2008 (Combined Data).

Weeks After Sowing

Treatments	Week_4	Week_8	Week_12	Week_16	Week_20	Week_24	Week_28
Panicle per plant	.606*	.603**	.618**	.518**	.518**	.590**	.152
Capsules per plant	.515**	.511**	.496**	.219**	.451**	.479**	.406**
Capsules per panicle	.203*	.261*	.398**	.507*	.377**	.460**	.073
Seeds per plant	.532**	.528**	.529**	.243**	.472**	.508**	.416**
Dry weight of harvestable Material	.774**	.782**	.654**	.324**	.668**	.659**	.449**
Total dry weight per plant	.649**	.710**	.633**	.411**	.642**	.663**	.268*
Harvest Index	.749**	.751**	.627**	.299**	.637**	.623**	.483**
Seed Yield	.624*	.595**	.522**	.368**	.561**	.533**	.460**
100 Seed weight	.302*	.342**	.361**	.373**	.512**	.489**	.256*
Oil Yield	.159**	.195**	.295**	.533**	.259**	.287*	.039

* Significant at P = 0.05
** Significant at P = 0.01

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