



## ASSOCIATION ANALYSIS AND CONTRIBUTION OF GROWTH AND YIELD CHARACTERS TO YIELD OF CASTOR IN BAUCHI STATE, NIGERIA

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### ABSTRACT

A field experiment was carried out at Abubakar Tafawa Balewa University teaching and research farm, Bauchi located in the Northern Guinea Savannah and Bulkachuwa village of Katagum LGA located in Sudan Savannah both in Bauchi State, during the rainy seasons of 2016, 2017 and 2018 to study the association of growth and yield characters and their contribution to the yield of castor. The treatments consisted of five nutrient sources (poultry manure, cow dung, chicken feather, municipal waste, mineral fertilizer) and a control and two varieties of castor (Ex-India 1 and 2), factorially combined to give 12 treatments and laid out in a randomized complete block design (RCBD) with three replications. The result of the experiment revealed a significant and positive relationship as well as direct and indirect contribution of characters to the yield of castor. Except leaf area index ( $r = 0.174^*$ ), number of capsules ( $r = 0.169^*$ ) and seed oil content ( $r = 0.139^*$ ) that were only significant at ( $P \leq 0.05$ ), all the parameters measured were positively related to grain yield. Except net assimilation rate ( $r = -0.643^{**}$ ), days to 50% flowering ( $r = -0.485^{**}$ ) and height to first raceme ( $r = -0.345^{**}$ ) that had negative relationship with grain yield, all other parameters exhibited a strong and positive relationship with castor grain yield. The result further indicated that, the direct contribution of plant height to seed yield was positive and highest. It was further observed that, the highest direct and negative contribution was observed with height to first raceme. It also showed that, direct and positive contribution to seed yield among the growth characters was only observed through plant height and crop growth rate. Yield characters on the other hand, a direct and positive contribution was observed with highest from 100 seed weight. Based on the results of this findings, improving characters that exhibit direct and positive contribution can improve the yield of castor in the study area.

**Keywords:** Association, Characters, Castor; Growth, Yield.

### INTRODUCTION

Recent studies and genetic improvements have increased the oil content of castor bean from 24 to 50% and the plant has also been bred to mature at a shorter height. Whereas the castor-oil plant traditionally reaches three meters in height, making mechanized harvest difficult, there are now varieties that grow to just 1.7 meters. These short varieties are mostly commercially grown in Europe (Soratto *et al.*, 2011). Castor bean does not compete with food crops, as it can be grown on marginal lands, which are not competing with food production lands. It is an uncomplicated crop that requires little attention during its growing periods. Due to its low demand on soil fertility, it is ideal for marginal lands to prevent desertification and erosion. Horton *et al.* (2006) observed in a series of experiments that, dry matter accumulation during ripening phase is greatly influenced by N and P application at the rate of 120 kg N/ha and 20 kg P/ha respectively. In another experiment, Tropilab (2006) asserted that optimum and



minimum temperatures of 30 and 22°C, respectively, are favourable for seed setting to maturity by providing 120 kg N/ha and 16 kg P/ha, in order to achieve maximum yield. Similarly, Horton *et al.* (2006) explained that “Aruna” variety grows best where temperatures are rather high throughout the season, but seed may fail to set if it is above 38°C for an extended period when fertilization rate is below 150 kg N/ha + 20 kg P/ha. It also prefers a pH of between 4.5 and 8.3.

Growth and seed yield of castor are usually determined by several inter-related components notably amongst these are the genetic make-up of the variety, the effect of the environment and to a large extent the level of field management (Nagabhushanam and Raghavaiah, 2005). There is a wide range of varieties of castor crop and they differ in their response to fertilizer rates, branching habit, seed types, colour of the stem and branches (red or green), the nature of capsules (smooth or shiny), duration and size and also colour of seeds (Tampio *et al.*, 2016). In addition, castor crop types, according to Ghush (2003) differ genetically in their potential productivity and their relative response to management practices especially fertilizer use, water management and field situation.

Severino *et al.* (2012) reported that castor varieties differ in their ability to partition dry matter into capsules and seeds in response to environmental factors and fertilizer doses. They further reported that the small seeded castor varieties are usually late maturing and thus more time could be allocated to the partitioning of assimilates into racemes, capsules and seeds. Fanan *et al.* (2009) also explained that higher seed yield in castor is associated with the crop adaptability to its environment be it the big seeded or the small seeded, provided there is adequate supply of N and P.

Zuchi *et al.* (2010) explained that the taller castor varieties when given adequate fertilization of 120 kg N/ha + 15 kg P/ha will produce higher number of raceme and seeds per capsule. This contributed significantly to their seed yield than the small seeded types. Also, from the findings of Tampio *et al.* (2016) the big seeded genotypes consistently showed higher CGR and LAI values after flowering than the small seeded varieties when the N level is above 100 kg/ha. Also, Vallejos *et al.*, (2011) reported that higher LAI to a great extent, determines biomass accumulation through its effects on radiation interception and photosynthetic activity. Severino *et al.* (2011) earlier reported that castor varieties differ in their ability to partition dry matter to seeds in response to environmental factors such as temperature and solar radiation intensity as these may have a significant effect on different phenological stages of growth. Despite many research conducted on fertilizer requirement for increased yield of castor, little is done on the association of characters and their contribution to growth and yield of castor. This experiment is therefore aimed at studying the association of growth and yield characters and their contribution to the yield of castor.

## **MATERIALS AND METHODS**

The field research was carried out at teaching and research farm of the Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University Bauchi, (10° 22'N and 9° 47'E) in the northern Guinea savanna ecological zone Bulkachuwa Village (11°38'N and 10°31'E) of Katagum LGA in the Sudan savanna ecological zone during the rainy seasons of 2016, 2017 and 2018 in Bauchi State of Nigeria. The treatments consisted of five nutrient sources (poultry manure, cow dung, chicken feather, municipal waste, NPK fertilizer and a control) and two cultivars of castor (Ex-India 1 and 2), factorially combined to give 12 treatments and laid out in a randomized complete block design (RCBD) with three replications.



The field was ploughed once and harrowed twice to a fine tilth during the first year using tractor drawn implement. However, manual tillage using hand hoe was carried out in the subsequent years so as to maintain plots and their treatments. The organic fertilizers (poultry manure, chicken feather, municipal waste and cowdung) were applied at the rate of 2 tons/ha after land preparation and worked into the soil at two weeks before sowing in both locations and in each year of the study. Inorganic fertilizer however was applied at the rate of 100 kg N, 50 kg P<sub>2</sub>O<sub>5</sub> and 50 kg K<sub>2</sub>O in two split doses. The complete dose of P and K with half dose of N (50:50:50) was applied at one week after emergence as basal application. The remaining half dose of N (50 kg) in the form of urea (46%N) however, was applied as top dress beside the plant and then covered with soil at 6 weeks after sowing (WAS). Data was collected on plant height, number of leaves, number of branches, leaf index, total dry matter, crop growth rate, net assimilation rate, number of days to 50% flowering and number of days to physiological maturity. Others are height to first raceme, number of raceme/plants, raceme length, number of capsules/racemes, 100 grain weight, grain yield and seed oil content. All data were subjected to combined analysis of variance (ANOVA) using the statistical analysis system procedure (SAS, 2003) and simple correlation was carried to assess the relationship among all the characters studied using statistical package for social science (SPSS version 22). Path coefficient analysis was also carried out to determine the extent of contribution of each character to yield using Analysis of Moment Structures (AMOS 22).

## RESULT AND DISCUSSION

### Simple Correlation of Seed Yield with Growth and Yield Characters

The result as presented in Table 1 revealed a significant ( $P \leq 0.001$ ) relationship between castor grain yield and other growth and yield characters measured. The result further indicated that, except leaf area index ( $r = 0.174^*$ ), number of capsules ( $r = 0.169^*$ ) and seed oil content ( $r = 0.139^*$ ) that were only significant at ( $P \leq 0.05$ ), all the parameters measured were positively related to grain yield. Yield parameters on the other hand, except net assimilation rate ( $r = -0.643^{**}$ ), days to 50% flowering ( $r = -0.485^{**}$ ) and height to first raceme ( $r = -0.345^{**}$ ) that had negative relationship with grain yield, all the other parameters exhibited a strong and positive relationship with castor grain yield.

The significant ( $P \leq 0.05$ ) and positive correlation which exists between castor seed yield and plant height ( $r = 0.483^{**}$ ), number of leaves ( $r = 0.322^{**}$ ) and number of branches ( $r = 0.545^{**}$ ) indicates the importance of these characters to the yield of castor. This revealed that, the taller the plant, the higher the number of leaves, the higher the number of branches and the higher the yield. This was not surprising, because it is the same plant height that have the strongest direct and positive effect (0.430) on grain yield. However, even though number of leaves (-0.191) and number of branches (-0.007) contributed negatively to seed yield, but their indirect positive contribution through other characters may not be overemphasized. This is in agreement with the report of Nagabhushanam and Raghavaiah (2005) that, positive relationship normally exists between growth and yield characters of castor.

The positive and significant correlation observed between leaf area index ( $r = 0.174^*$ ) and seed yield of castor revealed a significance of leaf area as a site of light interception for photosynthetic activities. This indicates that, the larger the assimilatory leaf area, the higher the amount of light intercepted and the higher the assimilate production and the higher the yield. Though path coefficient indicates a negative contribution (-0.132) of leaf area to seed yield, but contributed positively through other characters such as plant height, crop growth rate, net assimilation rate etc. The result of the present findings lend support from the findings of



Modelle (2002) that, leaf area and its index exhibit a positive correlation and may have a direct or indirect contribution to castor seed yield.

The highly significant correlation between grain yield and total dry matter ( $r = 0.363^{**}$ ) and crop growth rate ( $r = 0.264^{**}$ ) was expected because higher dry matter production and faster growth rate usually leads to translocation of more assimilate to the reproductive organs such as the grain that constitute the economic yield. This indicated that, the higher the dry matter accumulation, the higher the seed yield. Even though total dry matter had a negative direct contribution ( $-0.048$ ) to seed yield, but it positively contributed indirectly through other characters. However, direct and positive contribution ( $0.053$ ) to castor seed yield was observed under crop growth rate. Tampio *et al.* (2016) lend support to the present findings that, there is a significant contribution and relationship between plant dry weight and yield of castor.

Significant and negative correlation was observed between days to 50% flowering ( $-0.485^{**}$ ) and height to first raceme ( $-0.345^{**}$ ) indicating the importance of good vegetative development in producing high yield and also the interdependency within and between these characters. The inverse relationship of days to 50% flowering and height to first raceme with seed yield indicated that, the higher the number of days to 50% flowering the lower yield and vice-versa. Similarly, the shorter the height to first raceme the higher the chance for the crop to produce more branches with higher secondary raceme and total yield. This showed that, the earlier the flower the higher the chance for the castor to produce high primary and secondary raceme yield depending on the environmental factors. The present findings are in conformity with the report of Vallejos *et al.* (2011) that, earlier flowering and shorter stem length to first raceme in castor lead to higher grain yield. Though this depends on rainfall pattern and other environmental conditions.

The positive and highly significant ( $P \leq 0.05$ ) correlation observed between yield and yield characters such as number of capsules per raceme ( $r = 0.169^*$ ) and length of raceme per plant ( $r = 0.487^{**}$ ) suggests that, these characters were most critical determinants of seed yield in castor and thus constitute an important trait that should be considered by breeders for improvement. The significant and positive regression observed under number of capsules per raceme ( $r^2 = 9.979^*$ ) indicates the dependency of castor seed yield to number of capsules per raceme. This is not surprising when compared to positive and direct effect of number of capsules per raceme ( $0.132$ ) and length of raceme ( $0.184$ ) to grain yield. This finding is in conformity with that of Ghosh (2003) who noted a highly significant positive correlation between seed yield and vegetative growth, dry matter, seed oil content and some yield components in castor. The other growth and yield characters assessed made their highest indirect contributions through plant growth and seed yield. This further emphasized their importance to seed yield of castor.

The positive relationship observed with 100 seed weight ( $r = 0.420^{**}$ ), primary raceme yield ( $r = 0.578^*$ ) and secondary raceme yield ( $r = 0.386^{**}$ ) revealed that, these characters are critical determinants of yield in castor. The higher the number of capsules per raceme, the higher the 100 seed weight and the higher the yield. This is not surprising because a significant and positive regression was also observed under 100 seed weight ( $r^2 = 9.770^{**}$ ) and primary raceme yield ( $r^2 = 0.523^{**}$ ), indicating dependence of castor seed yield on these characters. The result of the present findings lends its support from that of Severino *et al.* (2006) who affirmed that, number of capsules per raceme and seed weight are the critical determinants of seed yield in castor.





**Table 1:** Simple Correlation of Seed Yield with Growth and Yield Characters

Character	Correlation	Mean	Standard Error
Yield	-	1364.02	39.33
Plant Height	0.483**	168.6	2.19
Number of Leaves	0.322**	18.86	0.30
Leaf Area Index	0.174*	0.32	0.01
Total Dry Matter	0.363**	128.87	2.38
Crop Growth Rate	0.264**	5.74	0.2
Net Assimilation Rate	-0.643**	3.01	0.11
Number of Branches	0.545**	5.64	0.86
Days to 50% Flowering	-0.485**	87.28	0.81
Height to First Raceme	-0.345**	33.27	0.95
Number of Capsules/Raceme	0.169*	37.91	0.99
Length of Raceme	0.487**	6.22	0.08
100 Seed Weight	0.420**	43.61	0.94
Primary Raceme Yield	0.578**	732.94	33.58
Secondary Raceme Yield	0.386**	202.41	9.36
Oil Content	0.139*	42.59	2.15

\*\* & \* = significant @ 0.01 & 0.05 probability level, respectively.

### Path Coefficient and Contribution of Growth and Yield Characters to Seed Yield

Table 2 presented result of the direct and indirect effect of growth and yield characters to grain yield. The result indicated that, out of the total correlation coefficients obtained, the direct contribution of plant height to seed yield was positive and highest. The result further revealed that, the highest direct and negative contribution was observed with height to first raceme. It also showed that, direct and positive contribution to seed yield among the growth characters was only observed through plant height and crop growth rate. All the other growth characters indicated a direct and negative contribution. The result also revealed that, all the yield characters exhibited a direct and positive contribution with highest contribution observed from 100 seed weight.

The highest direct effect of 100 seed weight (0.222) to grain yield indicated the importance of seed weight to the yield of castor. The direct and positive effect of primary (0.039) and secondary (0.123) raceme yield to grain yield indicated their importance in breeding for increase yield in castor. The result of this findings lends its support from the report of Soratto *et al.* (2011) that, yield component plays a great role and exhibit a direct positive contribution to the yield of castor. This result is also in line with the report of Fanan *et al.* (2009) who affirmed that, yield component increases the yield of castor either direct or indirectly. The result of this findings is not in agreement with the report of Zuchi *et al.* (2010) who reported that, the increase in one yield component does not always result in the proportional increase in seed yield because other components compensate for the contribution either directly or indirectly. The discrepancy between the two findings could be attributed to the variety use and location.



**Table 2:** Direct (bold and diagonally) and indirect effect of characters to seed yield

	PH	NL	LA I	TD M	CG R	NA R	NB	50F L	HF R	NC R	LR	SW 100	PR Y	SR Y	OC	TC
PH	<b>0.4</b> <b>30</b>	0.1 35	0.0 90	0.0 34	0.0 33	0.0 77	0.0 00	0.0 20	0.1 44	0.0 57	0.1 23	0.0 23	0.0 22	0.0 71	0.0 30	0.48 3**
NL	0.3 03	<b>0.1</b> <b>91</b>	0.0 80	0.0 33	0.0 35	0.0 68	0.0 00	0.0 17	0.1 21	0.0 78	0.1 34	0.0 20	0.0 3	0.0 79	0.0 29	0.32 2**
LAI	0.2 93	0.1 15	<b>0.1</b> <b>32</b>	0.0 32	0.0 31	0.0 59	0.0 02	0.0 18	0.2 67	0.0 57	0.1 20	0.0 07	0.0 21	0.0 77	0.0 36	0.17 4*
TD M	0.3 00	0.1 30	0.0 86	<b>0.0</b> <b>48</b>	0.0 47	0.0 69	0.0 00	0.0 20	0.1 62	0.0 55	0.1 43	0.0 33	0.0 24	0.0 68	0.0 29	0.36 3**
CG R	0.2 63	0.1 25	0.0 77	0.0 43	<b>0.0</b> <b>53</b>	0.0 54	0.0 00	0.0 16	0.1 80	0.0 56	0.1 33	0.0 05	0.0 20	0.0 61	0.0 28	0.26 4**
NA R	0.2 55	0.1 00	0.0 60	0.0 26	0.0 22	<b>0.1</b> <b>30</b>	0.2 34	0.0 20	0.0 41	0.0 55	0.1 27	0.0 53	0.0 30	0.0 70	0.0 27	0.64 3**
NB	0.0 18	0.0 13	0.0 43	0.0 03	0.0 01	0.0 45	<b>0.0</b> <b>07</b>	0.0 03	0.3 68	0.0 19	0.0 25	0.0 02	0.0 20	0.0 41	0.0 55	0.54 5**
50F L	0.2 99	0.1 11	0.0 80	0.0 34	0.0 30	0.0 89	0.0 01	<b>0.0</b> <b>29</b>	0.1 06	0.0 65	0.1 37	0.0 46	0.0 25	0.0 64	0.0 32	0.48 5**
HF R	0.1 39	0.0 52	0.0 79	0.0 18	0.0 21	0.0 12	0.0 06	0.0 07	<b>0.4</b> <b>47</b>	0.0 48	0.0 45	0.0 72	0.0 01	0.0 39	0.0 31	0.34 5**
NC R	0.1 84	0.1 12	0.0 57	0.0 20	0.0 23	0.0 54	0.0 01	0.0 14	0.1 61	<b>0.1</b> <b>32</b>	0.1 13	0.1 04	0.0 13	0.0 55	0.0 33	0.16 9*
LR	0.2 87	0.1 39	0.0 86	0.0 38	0.0 39	0.0 90	0.0 01	0.0 22	0.1 10	0.0 82	<b>0.1</b> <b>84</b>	0.0 17	0.0 28	0.0 77	0.0 36	0.48 7**
SW 100	0.0 45	0.0 17	0.0 04	0.0 07	0.0 01	0.0 31	0.0 03	0.0 06	0.1 45	0.0 62	0.0 14	<b>0.2</b> <b>22</b>	0.0 12	0.0 24	0.0 21	0.42 0**
PR Y	0.2 45	0.1 14	0.0 69	0.0 30	0.0 28	0.0 99	0.0 02	0.0 19	0.0 09	0.0 45	0.1 31	0.0 69	<b>0.0</b> <b>39</b>	0.0 85	0.0 25	0.57 8**
SR Y	0.2 47	0.1 23	0.0 82	0.0 27	0.0 26	0.0 75	0.0 01	0.0 15	0.1 43	0.0 59	0.1 15	0.0 43	0.0 27	<b>0.1</b> <b>23</b>	0.0 30	0.38 6**
OC	0.1 48	0.0 64	0.0 56	0.0 16	0.0 17	0.0 41	0.0 01	0.0 11	0.1 58	0.0 51	0.0 77	0.0 54	0.0 12	0.0 42	<b>0.0</b> <b>86</b>	0.13 9*

Residual effects = 0.34484; \*\* Correlation coefficients (r) at 5% level of probability.

PH = Plant height, NL = Number of leaves, LAI = Leaf area index, TDM = Total dry matter, CGR = Crop growth rate, NAR = Net assimilation rate, HFR = Height to first raceme, 50FL = Days to 50% flowering, NB = Number of branches, NCR = Number of capsules per raceme, LR = Length of raceme, 100SW = 100 Seed weight, PRY = Primary raceme yield, SRY = Secondary raceme yield, OC = Oil content & TC = Total correlation.

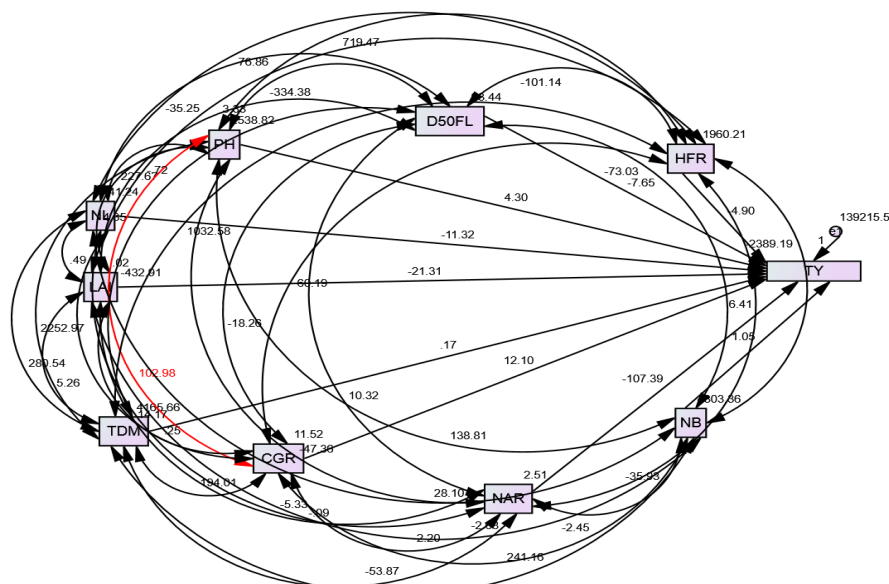


Figure 1: *Structural equation model showing direct and indirect contribution of growth characters to yield*

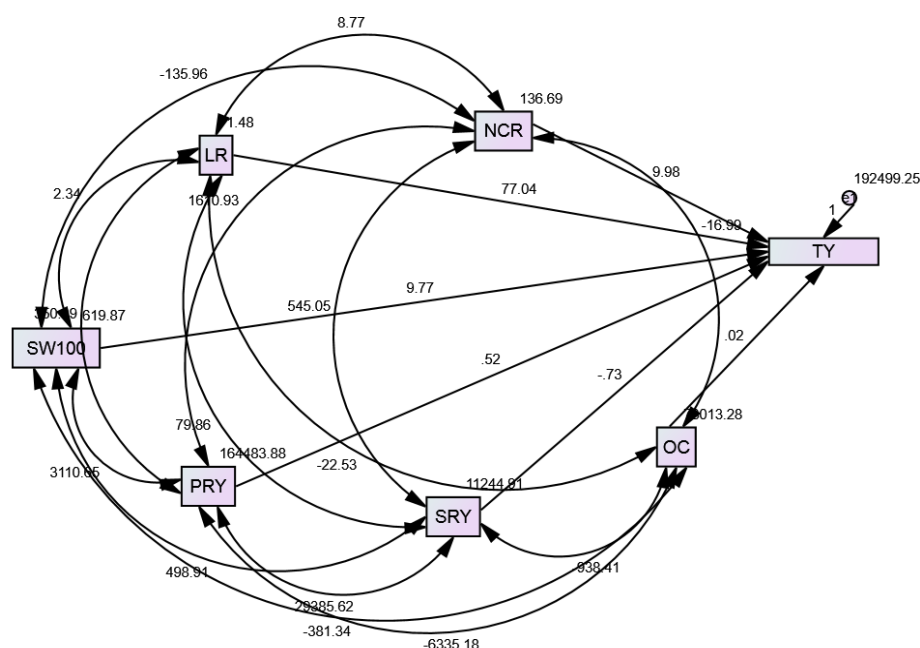


Figure 2: *Structural Equation Model Showing Direct and Indirect Contribution of Yield Components to Yield*

## CONCLUSION AND RECOMMENDATIONS

Based on the results of this findings, a strong relationship exists between growth and yield characters of castor. Furthermore, all the characters observed had a contribution to the yield of castor either directly or indirectly through other characters that exhibit direct contribution to the yield. Therefore, improving characters that exhibit direct and positive contribution can improve the yield of castor in the study area.



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