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Evaluation of yield and yield components of castor (*Ricinus communis l.*) germplasm from rain forest and southern guinea savannah agro-ecological zones of Nigeria

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KEYWORDS

Equation, Harvest, Indices, Panicle, Regression, Stepwise

A B S T R A C T

Forty-two castor accessions were evaluated at the Teaching and Research Farm of the University of Agriculture, Makurdi. Randomized Complete Block Design (RCBD) with three replications was used. Four-row plots of 5.5 m lengths were seeded to 11 hills of two seeds that were thinned to single stand per hill .The rows were 1m apart and the hills were spaced 0.5 m intra-row. The two middle rows of a total of 22 plants in a plot were used for observation. Variations existed from the primary to the tertiary panicles in yield components per panicle types of the germplasm. There were sequential per centage decreases in number of capsules, 100-seed weight and seed yield per panicle types from primary to penterimary panicles. Over 85% of the seed yield components each were captured from primary to quarternary panicles. From the stepwise regression analysis, secondary panicle alone fitted into the yield equation contributed 57.6% of the total seed yield. While primary to quarternary panicles yielded 88.4% of the total seed yield. This implies that research, in this indeterminate crop, could be terminated after the harvest of the quarternary panicles without distorting the yield trends of the crop.

Introduction

There exists variability in living organisms that are endowed by nature. Breeding programmes manipulate such variations for the benefit of humanity. Without variation there would be no genetic improvement. Therefore, crop improvement depends on genetic variability in breeding materials, since selection does not create variability, but only acts on the existing variability.

To capture the natural variability that can be useful to breeding programmes, germplasm collection is of paramount importance. The principal justification for plant collection is to obtain natural variability that can broaden the germplasm pool for crop improvement (Bennett, 1979). Castor plant varies greatly in its growth habit; colour of foliage and stem, seed size, seed colour and seed oil content, so that varieties often bear little resemblance to each other (Weiss, 1971). Kulkarni (1959) observed that the crop has diverse variability, which could be used for genetic studies, yet not much work has been done on the genetics of the crop.

Variations exist in both yield and agronomic traits. The yield characters include: panicles, capsules and 100-seed weight as well as seed yield. Panicle number is a seed yield component. The panicles are borne terminally on the main and lateral branches. They are designated as primary, secondary, tertiary, etc panicles. The main stem ends in a primary panicle, usually the longest on the plant (Weiss, 1971; Brigham, 1980). There are varietal differences in this character. Hooks *et al*. (1971) and Uguru (2000) recorded ranges of 3.1 to 7.5 and 2 to 36 panicles per plant, respectively.

Capsule number depends on the proportion of pistillate flowers on the panicle. This is a function of the variety. Uguru (2000) reported a range of 84 to 530 capsules per plant.

Seed yield per plant and 100-seed weight vary with variety and with the type of panicle. Kittock and Williams (1967) reported that 100-seed weight from primary panicle was always the highest when compared to the secondary, tertiary and quaternary panicles. Similarly, Kittock and Williams (1968) reported percentage distribution of seed yield per panicle sequentially as: primary panicle, 25%; secondary panicle, 45%; tertiary panicle, 20%; quaternary panicle, 8%; and the penternary panicle, 0.5%. Weiss (1971) reported the highest seed yield per panicle for primary panicle, while successive panicles produced progressively lower seed yields. Uguru (2000) recorded ranges of 90.2 to 507.2 g for seed yield per plant and 11.92 to 51.7 g for 100-seed weight. Gobin *et al*. (2001) reported that the mean seed yield ranged as from 500 kg/hectare in India to 1000 kg/hectare in Thailand and 2500 kg/hectare under improved conditions in USA. However, recent report showed that 554 kg/hectare was obtained in Brazil, 600 kg/hectare in Russian Federations, 621 kg/hectare in Romania, 626 kg/hectare in Thailand, 667 kg/hectare in Sudan, 700 kg/hectare in Ukraine, 909 kg/hectare in China and 1,266 kg/hectare in India (FAO, 2000).

Materials and Methods

A germplasm of 98 accessions, collected from the Rain Forest and Southern Guinea Savanna agro-ecological zones of Nigeria was assembled in Makurdi. From this collection, forty-two accessions were selected because they had sufficient seed for agronomic evaluation and characterization.

The forty-two accessions were evaluated at the Teaching and Research Farm of the University of Agriculture, Makurdi. Randomized Complete Block Design (RCBD) with three replications was used. The land was ploughed and harrowed. With a Tractor, NPK 15-15-15 compound fertilizer was broadcast before ridging at the rate of 300 kg/hectare. Four-row plots of 5.5 m lengths were seeded to 11 hills of two seeds that were thinned to single stand per hill .The rows were 1m apart and the hills were spaced 0.5 m intra-row. The two middles rows of a total of 22 plants in a plot were used for observation. Weed control was manually done four weeks after planting. The same type of fertilizer was used to top-dress after weeding at the rate of 150 kg/hectare.

Data were collected on the following characters: number of capsules, 100-seed weight and seed yield by panicle type. The means of data by replicates were subjected to analysis of variance. Pearson product–moment correlation analysis between the yield components per multiple panicle types, and stepwise regression analysis were carried out to determine the panicle types that fitted into the yield equation. SAS programme was used for the analyses.

Results and Discussion

The mean square estimates of yield components in various panicle types are presented in Table 1. There was significant variation among the accessions with respect to the components from primary to tertiary panicle except for seed yield in the tertiary panicle. The number of capsules and 100-seed weight, among the accessions were highly significant ($P< 0.01$) from primary to tertiary panicle, while on other hand, seed yield recorded significant ($P<0.05$) variation among the accessions in primary and secondary panicles.

The percentage contributions of various panicle types to some yield components decreased sequentially from primary to penternary panicles (Table2). The primary to tertiary panicles contributed 70.47% to the number of capsules, 70.95% to 100-seed weight and 71.45% to seed yield.

Correlation and regression analyses

Table 3 shows coefficients of correlation among seed weight of various panicle types and total seed yield. There were significant positive correlations among the seed weights of the primary, secondary and tertiary panicles as well as between the tertiary panicle and the penternary panicle. However, only the quaternary panicle has significant positive correlation with the total seed yield.

The stepwise regression analysis in Table 4 revealed the relative contributions of the panicle variables in predicting the total seed yield of castor. When only the secondary panicle was fitted in the yield equation, its contribution was 57.6%. Similarly, the quaternary panicle contributed 19.5%, quaternary and primary panicles added 7.0%, whereas quaternary, primary and tertiary panicles contributed 4.3% when each was fitted along with the secondary panicle in the regression equation. In essence, from primary panicle to quaternary panicle, 88.4% of the total yield in castor was realized in this study. The regression equations are listed in Table 5 as four selection indices. The use of secondary panicle alone as a selection index would capture 57.6% of the total yield per plant, while the use of secondary and quaternary panicles together, as a selection index would capture additional 19.5% of the total yield per plant.

Furthermore, the use of secondary, quaternary and primary panicles as well as secondary, quaternary, primary and tertiary panicles would capture additional 7.0 and 4.3% of the total yield per plant, respectively.

The variation that existed in the yield components studied in the castor accessions showed that castor seed yield could be improved upon through selection programmes if genetic information on how these characters are inherited is known.

Similar variations were reported on yield (Hooks *et al.,* 1971); 100- seed weight and seed yield (Giriraj *et al*., 1973); seed yield per plant (Bhatt and Reddy, 1983); seed yield, and 100-seed weight (Bhardwaj *et al.*, 1996); 100-seed weight and seed yield (Uguru, 2000).

Table.1 Mean square estimates for yield components on various panicle types of some selected castor accessions

Sources of variation	**Df**	**Primary panicle**			**Secondary panicle**			**Tertiary panicle**			**Quaternary panicle**			**Penternary panicle †**		
		NC	SW100 (g)	SY (g)	NC	SW100 (g)	SY (g)	NC	SW100 (g)	SY(g)	NC	SW100 (g)	SY(g)	NC	SW100 (g)	SY (g)
Rep	2	1251.38**	263.29	134.81**	768.13**	6.98	18.80	213.16**	226.00	24.96*	31.60	59.21	3.77	32.31	1.56	0.62
Entry	41	226.54**	940.55**	18.51*	213.60**	1066.29**	16.38*	57.80**	765.92**	5.49	25.35	191.04	1.24	23.92	5.82	4.64
Error ‡	82	114.94	139.96	12.07	88.09	7.62	11.42	27.59	107.12	5.14	23.13	121.39	1.48	30.56	4.39	4.41

*, ** Significant at probability levels of 0.05 and 0.01, respectively.
† Penternary panicle and above
KEY:
NC = number of capsule/panicle;

SW100 = 100 seed weight (g);

SY = Seed yield (g)/ panicle.

‡ Variations in degree of freedom (df) of error mean square for the three yield components by panicle type are as follows:

	NC	SW100	SY
Primary	-5	-14	-7
Secondary	-8	-10	-8
Tertiary	-17	-18	-13
Quaternary	-36	-39	-31
Penternary	-52	-56	-5

Table.2 Percentage contributions of various panicle types to some seed yield components in some selected castor accessions

Seed yield Component	Primary Panicle	Secondary Panicle	Tertiary panicle	Quaternary Panicle	Penternary panicle †	Total%
NC	29.27	21.95	19.25	16.56	14.95	100.0
SW100	24.54	23.86	22.55	16.57	12.48	100.0
SY	30.01	22.68	18.76	14.12	14.43	100.0

† = 5th panicle and above.

KEY

NC = Number of capsule per panicle;

SW100 = 100-seed weight (g);

SY = Seed yield (g) per panicle.

Table.3 Coefficients of correlation among seed weight of various panicle types and total seed yield of some selected castor accessions

Panicle type	Primary Panicle seed wt.	Secondary Panicle Seed wt	Tertiary Panicle seed wt	Quaternary Panicle seed wt	Penternary Panicle seed wt	Total Seed yield.
Primary Panicle Seed wt.	1.000	0.590**	0.398**	0.042	0.143	0.185
Secondary Panicle Seed wt.		1.000	0.535**	-0.056	0.052	0.083
Tertiary Panicle Seed wt.			1.000	0.033	0.318*	0.130
Quaternary Panicle Seed wt.				1.000	0.262	0.959**
Penternary Panicle Seed wt.					1.000	0.245

*, ** Significant at probability levels of 0.05 and 0.01, respectively

Table.4 Relative contributions of seed of various panicle types to total seedyield of seclected castor accessions

Variable	Constant	Reg.Coef.	R	R^2 Change	F	Significant
Secondary panicle	6.828	2.443	0.759	0.576	39.500	0.000
Secondary panicle	1.792	1.751	0.878	0.195	47.092	0.000
Quaternary panicle		3.342				
Secondary panicle	-1.206	1.361	0.917	0.070	47.364	0.000
Quaternary panicle		3.452				
Primary panicle		0.858				
Secondary panicle	2.933	1.099	0.940	0.043	49.093	0.000
Quaternary panicle		2.040				
Primary panicle		0.940				
Tertiary panicle		1.947				

Table.5 Regression equations for the panicle variables

Panicle Variables	Regression Equations
Secondary panicle	$\hat{Y} = 6.828 + 2.443X_2 + \Sigma ij.$
Secondary and quaternary Panicles	$\hat{Y} = 1.792 + 1.751X_2 + 3.342X_4 + \Sigma ij.$
Secondary, quaternary and Primary panicles	$\hat{Y} = 1.206 + 1.361 X_2 + 3.452 X_4 + 0.858X_1 + \Sigma ij.$
Secondary, quaternary, primary and tertiary panicles	$\hat{Y} = 2.933 + 1.099 X_2 + 2.040 X_4 + 0.941X_1 + 1.949X_3 + \Sigma ij.$

KEY: X_1 = primary panicle; X_2 = secondary panicle; X_3 = tertiary panicle; X_4 = quaternary panicle

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The progressive decrease in percentage of sequential number of capsules, 100-seed weight and seed yield per panicle type from primary to penternary panicles agrees with earlier patterns reported by Kittock and Williams (1967) and percentage yield decrease in seed yield per sequential panicle type agrees with the reports of Kittock and Williams (1968) and Weiss (1971). The progressive decrease in sequential yield components might be as a result of either mouldy or abortive nature of flowers during the cloudy and high rainfall months (July to September) or some natural phenomena where panicle size decreased with more branching. The sequential decrease in yield components with more branching could be attributed to competition for photosynthates by the many numerous sites on many panicles as compared to the primary and secondary panicles, with fewer storage sites. Furthermore, this could be attributed to some environmental factors like low rainfall associated with drier months from October to December where water stress could result in poor seed filling. The formation of tertiary panicles usually coincides with this period of water stress, a possible reason for poor seed filling.

Seed yield is a complex character and it is polygenic in inheritance (Singh and Bains, 1968). Therefore, selection for seed yield *per se* may be difficult due to the low heritability of the character (Allard, 1956). However, certain characters, which may be strongly related with seed yield, may be more heritable than the seed yield. If such components are selected for, better success may be achieved in seed yield improvement

Conclusion

The study revealed considerable variability in most of the castor accessions for the characters studied. The contribution to the yield components by panicle type decreased sequentially from primary to penternary panicles. Harvest up to the quaternary panicle captured over 85% of the number of capsules, 100-seed weight and seed yield of the plants. Similarly, stepwise regression analysis attributed 88.4% of the variation in total seed yield to yield from primary to quaternary panicles. Therefore, harvest of yield component data could be terminated after the quaternary panicles without distortion to yield trend, thereby solving the problem of continuous harvest in the indeterminate plants.

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