Combining Ability and Heterosis of Oil Content in Six Accessions of Castor at Makurdi

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ABSTRACT: Six accessions of castor viz: - Mkd. Acc. 1, Mkd. Acc. 7, Mkd. Acc. 12, Mkd. Acc. 13, Mkd. Acc. 14 and Mkd. Acc. 27 were subjected to combining ability test. The study was conducted at the University of Agriculture, Makurdi in 2004 and 2005 planting seasons. The objective was to determine the effect of crossing on the oil content of these castor accessions. A Randomized Complete Block Design (RCBD) was used with three replications. The study revealed that oil content of castor seeds of the accessions used varies from 36.6% - 53.85%. Analysis of variance revealed significant differences for entries, parents and hybrids. The analysis for combining ability showed that GCA and SCA were significant in each of the year. This is an indication that both additive and non-additive gene actions are important in the inheritance of oil in castor. Percentage heterosis of the hybrids for the 2 years showed that in 2004, 9 hybrids had higher oil content than their mid-parent value. 7 hybrids had higher oil content than the better parent In 2005, 11 hybrids had higher oil content than the mid-parent value; and 8 hybrids had higher oil content than their better parent. This study revealed that heterosis existed among the parents used. The results indicates high chances that the hybrid vigour may be exploited in a breeding programme to improve castor oil content. [Nature and Science. 2007;5(4):18-23].

Keywords: Castor Accessions, heterosis, combining ability, Makurdi, Oil content.

INTRODUCTION

Castor plant which is essentially a tropical species (Weiss, 1983) can grow in all the states in Nigeria. Castor oil is derived from castor plant (*Ricinus communis* L.). It is a colourless to very pale yellow liquid with mild or no odour or taste. Castor oil has over 1000 industrial uses and because of this, its demand increases (Uguru and Abuka, 1998). A scientific investigation of the crop to improve its oil content will go a long way to meet up with the demand.

Utilization of hybrid vigour for higher yield and better quality products have been exploited in many crops including soyabean (Kaw and Menson, 1979), cowpea (Zaveri *et al.*, 1983) and Sorghum (Verma and singh, 1983). Gila *et al.* (2005) reported heterosis in some agronomic characters in Castor crosses. This study however, did not consider the oil content of castor. Estimates of Specific combining ability (SCA) and General combining ability (GCA) will also assist in determining the best combining parents that will be used in developing aspect for higher oil content.

This research effort is therefore to investigate the oil content of the castor accessions in Makurdi. The specify Objectives of this study are: (i) to determine the oil content in the accessions of castor; (ii) to estimate the GCA and SCA variances in these castor accessions.

Materials and Methods

Six accessions of castor viz:- Mkd. Acc. 1, Mkd. Acc. 7, Mkd. Acc. 12, Mkd. Acc. 13, Mkd. Acc. 14 and Mkd. Acc. 27 were selected from a germplasm evaluation based on their yield performance (Gila 2003, unpublished) and used as parents. These parents were crossed in a partial diallel to generate 15 hybrids. The parents and hybrids were planted for evaluation in a Randomized Complete Block Design (RCBD) with three replications, in 2004 and 2005.

The study was conducted at the University of Agriculture, Makurdi on Latitude $7^{0}41^{1}$ and Longitude $8^{0}37^{1}$. The agronomic practices were manually done. Single row plots were used, each 3m long and spaced 1m x 0.5m. Clean seeds from each plot were grounded into a paste using mortar and pestle.

Oil Extraction

The Flask was washed, dried and weighed. 200ml of petroleum spirit was poured into a quick fit round bottom flask. Ten grammes of the sample were placed in the thimble and were inserted in the centre of the extractor. Heat was supplied at 60^{0}C. When the solvent was boiling, the vapour rises through the vertical tube into the extractor at the middle. The condensed vapour drips into the thimble in the centre, which contains the solid sample to be extracted wrapped in a filter paper.

The extract seeps through the pores of the thimble and fills the siphon tube, where it flows back into the quick fit round bottom flask. This was allowed for 8 hours.

The Petroleum spirit was recovered from the quick fit bottom flask. It was then dried in the oven and cooled in the desiccators, and weighed using mettler electronic balance.

Weight of oil = Weight of flask + oil - Weight of empty flask

$$\frac{\text{wt of oil}}{\text{wt of sample}} \times 100 = \%\ \text{oil}$$

Percentage oil content was analyzed using ANOVA for each year separately because homogeneity of error variance did not exist. The sources of variation were further partitioned into GCA and SCA. The Model 1, Method 2 of Griffing (1956) was used for the analysis as presented by Singh and Chaudhary (1977).

Result and Discussion

Significant differences (P = 0.01) were found among the 21 entries. Parents and hybrids were significant for the two years as revealed by analysis of variance (Table 1).

Table 1: Sources, Degree of Freedom and Mean Squares from Analysis of Variance of Castor Accessions in 2004 and 2005 Cropping Season.

Sources	**d.f.**	**Mean squares**	
		2004	**2005**
Entries	20	18.83**	44.83**
Rep	2	0.008	0.0006
Parent	5	11.33**	24.48**
Hybrid	14	21.64**	46.44**
P vs H	1	17.11**	103.99**
Error	4	0.23	0.0023
Total	**62**		

** = Significant at 1%

The mean oil content of the entries in 2004 and 2005 is shown in Table 2. In 2004, the following parents (Mkd Acc. 12 and Mkd Acc. 7) have the highest oil content of 45.27% and 44.26%, respectively; while Mkd Acc. 14 have the lowest oil content. Among the crosses, Mkd Acc.1 x Mkd Acc. 13, Mkd Acc. 7 x Mkd Acc. 14 and Mkd Acc. 13 x Mkd Acc. 14 had the highest oil content of 48.28%, 47.50% and 45.17% respectively. In 2005, the following parents Mkd Acc. 12 and Mkd Acc. 13 had the highest significant per ent oil content of 45.93% and 42.88% respectively. Mkd Acc. 7 had the lowest oil content of 36.6%. Among the crosses, Mkd Acc. 7 x Mkd Acc. 13, Mkd Acc. 1 x Mkd Acc. 13 and Mkd Acc. 13 x Mkd Acc. 14 had the highest oil content of 53.85%, 48.35% and 48.10% respectively, while Mkd Acc. 1 x Mkd Acc. 7 had the lowest oil content of 39.55%. In Table 2, parents and hybrid means revealed slight variations in magnitude. The means for each entry were not exactly the same for the 2 years. Kulkarni (1959) reported that the rate of oil content varies from year to year, indicating that seasons have considerable effect on the rate of formation of oil. In this study, generally oil content varies from 36.6% - 53.85% (Table 2). This collaborates with the study of Akpan *et al*, 2006 that reported 30 – 55% oil content.

The following crosses have higher oil content than their parent: Mkd Acc 1 x Mkd Acc 13, Mkd Acc 1 x Mkd Acc 14, Mkd Acc 7 x Mkd Acc 13, Mkd Acc 7 x Mkd Acc 14, Mkd Acc 13 x Mkd Acc 14, Mkd Acc 13 x Mkd Acc 27, and Mkd Acc 14 x Mkd Acc 27. The crosses Mkd Acc 1 x Mkd Acc 12, Mkd Acc 1 x Mkd. Acc. 27, Mkd Acc 12 x Mkd Acc 13, Mkd Acc 12 x Mkd Acc 14, Mkd Acc 12 x Mkd Acc 27 have higher oil content than one of the parents in 2004 (Table 2). In 2005, crosses Mkd Acc 1 x Mkd Acc 13, Mkd Acc 1 x Mkd Acc 14, Mkd Acc 1 x Mkd Acc 27, Mkd Acc 7 x Mkd Acc 13, Mkd Acc 7 x Mkd Acc 14, Mkd Acc 7 x Mkd Acc 27, Mkd Acc 13 x Mkd Acc 14 and Mkd Acc 14 x Mkd Acc 27 have higher oil content than either of the parents; while crosses Mkd Acc 1 x Mkd. Acc. 7, Mkd Acc 1 x Mkd Acc 12, Mkd Acc 7 x Mkd Acc 12, Mkd Acc 12 x Mkd Acc 14 have higher oil content than the other parent but less than Mkd. Acc. 12 (Table 2).

Table 2: Mean Percent Oil Content for Castor Accessions in 2004 and 2005 Cropping Season.

Entries	**Percent Oil**	
	2004	**2005**
Parents		
Mkd. Acc. 1	40.84	40.27
Mkd. Acc. 7	44.26	36.6
Mkd. Acc. 12	45.27	45.93
Mkd. Acc. 13	42.04	42.88
Mkd. Acc. 14	40.27	41.73
Mkd. Acc. 27	42.5	42.10
LSD (0.05)	1.28	0.10
CROSSES		
Mkd. Acc. 1 x Mkd. Acc. 7	37.93	39.55
Mkd. Acc. 1 x Mkd. Acc. 12	41.25	41.25
Mkd. Acc. 1 x Mkd. Acc. 13	48.28	48.35
Mkd. Acc. 1 x Mkd. Acc. 14	44.92	45.9
Mkd. Acc. 1 x Mkd. Acc. 27	41.07	46.55
Mkd. Acc. 7 x Mkd. Acc. 12	41.55	41.82
Mkd. Acc. 7 x Mkd. Acc. 13	45.90	53.85
Mkd. Acc. 7 x Mkd. Acc. 14	47.50	47.42
Mkd. Acc. 7 x Mkd. Acc. 27	42.29	42.17
Mkd. Acc.12 x Mkd. Acc. 13	42.88	41.73
Mkd. Acc.12 x Mkd. Acc. 14	44.15	44.87
Mkd. Acc.12 x Mkd. Acc. 27	44.98	41.85
Mkd. Acc.13 x Mkd. Acc. 14	45.17	48.1
Mkd. Acc.13 x Mkd. Acc. 27	42.72	39.73
Mkd. Acc.14 x Mkd. Acc. 27	44.52	43.43
LSD (0.05)	0.57	0.074

Table 3 shows that analysis for combining ability revealed that GCA and SCA were significant (P = 0.01). Giriraj *et al* (1973) and Hooks *et al* (1971) reported that both additive and non-additive gene actions were important for oil content in castor. This suggests that additive and non-additive genes are responsible for controlling the inheritance of oil in castor.

Table 3: Sources, Degree of Freedom (D.F) and Mean Squares from Analysis of Combining Ability for Castor Accessions in 2004 and 2005 Cropping Seasons.

Source	**d.f.**	**Mean squares**	
		2004	2005
GCA	5	3.09**	9.18**
SCA	14	7.83**	17.84**
Error	40	0.08	0.00082

** = Significant at 1%

In this study, the GCA and SCA ratios of 1:19 and 1:14 in 2004 and 2005, respectively, showed that SCA contributes more to the inheritance of oil in castor.

Table 4: Estimates of The GCA and SCA Effects for Oil in 6 X 6 Crosses of Castor Accessions at Makurdi in 2004 and 2005 Cropping Season.

ENTRIES	**GCA EFFECTS**	
	2004	**2005**
PARENT		
Mkd. Acc. 1	-1.037	-1.40
Mkd. Acc. 7	0.33	-0.92
Mkd. Acc. 12	0.24	-0.25
Mkd. Acc. 13	0.7	1.52
Mkd. Acc. 14	0.42	0.97

Mkd. Acc. 27	-0.356	-0.93
S.E. (gi)	0.57	0.059
CROSSES	**SCA EFFECTS**	
Mkd. Acc. 1 x Mkd. Acc. 7	-4.42	-2.76
Mkd. Acc. 1 x Mkd. Acc. 12	-1.31	-1.73
Mkd. Acc. 1 x Mkd. Acc. 13	5.26	3.61
Mkd. Acc. 1 x Mkd. Acc. 14	2.18	1.71
Mkd. Acc. 1 x Mkd.Acc. 27	-0.87	4.27
Mkd. Acc. 7 x Mkd. Acc. 12	-2.11	-0.63
Mkd. Acc. 7 x Mkd. Acc. 13	1.81	14.93
Mkd. Acc. 7 x Mkd. Acc. 14	3.69	3.42
Mkd. Acc. 7 x Mkd. Acc. 27	-0.74	0.39
Mkd. Acc. 12 x Mkd. Acc. 13	-1.42	-2.87
Mkd. Acc. 12 x Mkd. Acc. 14	0.13	0.21
Mkd. Acc. 12 x Mkd. Acc. 27	1.71	-0.59
Mkd. Acc. 13 x Mkd. Acc. 14	0.69	1.98
Mkd. Acc. 13 x Mkd. Acc. 27	-0.98	-4.18
Mkd. Acc. 14 x Mkd. Acc. 27	1.10	-0.54
S.E. (Sii)	0.43	0.043

The larger SCA indicate preponderance of non-additive type of gene effects. The non-additive genetic variation can be successfully exploited for the development of hybrids. This can be utilized through multiple crossing.

The GCA effects ranged from –1.037 to 0.7, while SCA ranged from –4.42 to 5.26 in 2004. In 2005, the GCA effects ranged from –1.40 to 1.52, while the SCA ranged from –4.18 to 14.93 (Table 4). Mkd. Acc. 13 is the best combiner among these parents because it had the highest GCA effects of 0.7 and 1.52 in the 2 years. The best specific combiner for 2004 was Mkd. Acc. 1 x Mkd. Acc. 13; with SCA effect of 5.26. The best specific combiner for 2005 was Mkd. Acc. 7 x Mkd. Acc. 13 (Table 4).

Percentage heterosis of the hybrids for the 2 years showed that in 2004, 9 hybrids had higher oil content than their mid-parent value. 7 hybrids had higher oil content than the better parent (Table 5). In 2005, 11 hybrids had higher oil content than the mid-parent value; and 8 hybrids had higher oil content than their better parent. This study revealed that heterosis existed among the parents used.

Table 5: Percentage Heterosis of the Castor Hybrids in 2004 and 2005 Cropping Seasons.

Crosses		2004	2005
Mkd. Acc.1 x Mkd. Acc.7	x 1	-10.85	2.89
	x 2	-14.30	-1.79
Mkd. Acc.1 x Mkd. Acc.12	x 1	-4.23	-4.29
	x 2	-8.90	-10.19
Mkd. Acc.1 x Mkd. Acc.13	x 1	16.51	16.31
	x 2	14.84	12.76
Mkd. Acc.1 x Mkd. Acc.14	x 1	10.75	11.95
	x 2	9.99	9.99
Mkd. Acc.1 x Mkd. Acc.27	x 1	-1.44	13.01
	x 2	-3.36	10.57
Mkd. Acc.1 x Mkd. Acc.12	x 1	-7.19	1.33
	x 2	-8.22	-8.95
Mkd. Acc.1 x Mkd. Acc.13	x 1	6.35	34.19
	x 2	3.71	25.58
Mkd. Acc.1 x Mkd. Acc.14	x 1	11	21.06
	x 2	7.32	13.64
Mkd. Acc.1 x Mkd. Acc.27	x 1	-2.51	7.17
	x 2	-4.45	0.17
Mkd. Acc.1 x Mkd. Acc.13	x 1	-1.79	-6.03
	x 2	-5.28	-9.14

Mkd. Acc.1 x Mkd. Acc.14	x 1	3.23	2.37
	x 2	-2.47	-2.31
Mkd. Acc.1 x Mkd. Acc.27	x 1	2.48	4.57
	x 2	-0.64	-8.88
Mkd. Acc.1 x Mkd. Acc.14	x 1	9.42	13.68
	x 2	7.45	12.17
Mkd. Acc.1 x Mkd. Acc.27	x 1	1.06	-6.50
	x 2	0.5	-7.55
Mkd. Acc.1 x Mkd. Acc.27	x 1	7.56	3.60
	x 2	4.75	3.16

X1 = Mid-parent **X2 = Better parent**

Conclusion

The percentage oil content from accessions of castor used in this study was found to be 36.6 – 53.85%.

Additive and non-additive gene actions were also seen to be important in the inheritance of oil in castor. Since the GCA effect was significant, selection of diverse parents may be exploited. This could lead meaningful hybridization of parents with high GCA effect to get more segregants. Segregants that expressed hybrid vigour could be ultilized in improving on the oil content of castor. The breeding programme, for increasing oil content should take into account the additive and non-additive gene actions observed herein the study.

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