

Original Research Article

Responses of Castor Beans Hybrids Produced by the Conventional Method and by the Cryptic Hybrid Method

ABSTRACT

Due to As a consequence of populations population's improvement, new ideas and methods emerged, seeking to improve efficiency of obtaining lines and hybrids, as well as decrease the time required in obtaining it. In this context, the Cryptic Hybrids method appears as an alternative to these questions, which can be configured as an effective tool in breeding programs of species that have the mixed type reproductive system. Thus, the objective of this study was to analyze the answers of hybrids produced by the conventional method and by the cryptic hybrid method. Experiments to evaluate hybrids on grain productivity were developed in the 2006/2007, 2007/2008 and 2008/2009 agricultural years simultaneously in the municipalities of Lins-SP and Penápolis-SP. This was, all conducted using under the randomized block design with four replicates. The oil productivity and plant height were determined over being that in the last two years the oil content, the oil productivity and the height of the plants were also determined. The results of the castor hybrids grain and oil productivity results of the castor hybrids demonstrated the ability of the cryptic hybrids to overcome the hybrids obtained conventionally. In addition, it was verified that there were no differences in the oil content of the seeds as a function of the method of obtaining hybrids. Regarding the size of the plants, it was observed the existence of cryptic hybrids with good agronomic characteristics and low size, yet, compared to conventional hybrids, has, on average, greater stature. Thus, the Cryptic Hybrids method was efficient to obtain superior lines and hybrids of castor bean, when compared to conventional "Standard" method.

Keywords: *inbred lines; allogamous species; mixed species; double cryptic hybrids.*

1. INTRODUCTION

Hybridization in the broader sense is of great interest in the improvement of most cultivated species, both for the exploration of heterosis and for the promotion of genetic variability in populations. Several types of hybrids can be synthesized, the most important being those obtained with the use of inbred lines [1].

The development of lines of hybrids has been mainly done by the so-called "Standard" method. The base populations, made up of adapted varieties of open population, are self-fertilized. Selection is practiced between and within the lineages until they reach a good level of homozygosity. These lines are selected in a set of crosses called "topcross" and later evaluated for specific combining ability. The genetic fixation in the lineages is random and nothing is known about the combinatorial ability until they are obtained. The time taken to obtain and evaluate the lineages is very large, making the conventional process of production of hybrid long and costly [1].

However, several attempts have been suggested to make it more efficient in the obtaining of lines of good combinatorial capacity. Many methods for improving lineages have been used with relative success, but always dependent on the pre-existence of superior lines, corroborating, thus, for that the "Standard" is still the most used in the various programs of plant breeding, with considerable success [2].

Comment [DA1]: Overall, the rationale and scientific methods used were well explained and good but i will advise that this manuscript be given to English editor to improve its quality more.

31 Regarding the inherent problems of the "Standard" method of obtaining lines, [3] report another
32 methodology, in which the method is based on the behavior of cryptic hybrids, and needs prolific
33 populations for its execution. This is necessary because self-fertilizations and crosses occur
34 simultaneously in the same plant. Maximum emphasis is placed on the selection of lines that have high
35 specific capacity of combination, where each generation in which is tested each generation for self-
36 fertilization. At the end of the program, the lines are obtained in simple combinations, which can later be
37 used in the synthesis of different types of hybrids [4].

38
39 One of the main explicit observations about the method, if not the main one, is that the Cryptic Hybrid
40 presented very limited use in breeding programs of allogamous species, preponderantly by the excessive
41 loss of vigor of the female line with the endogamy series. Of course the massive production of F1 seeds,
42 with a view to commercial hybridization, requires highly productive females, in due to relatively low levels
43 of inbreeding depression. The vigor of the female lines is indispensable for the hybrid seed to be
44 affordable to the farmer [5].

45
46 The observed exposure of the use of the method in allogamous, it is assumed that the Cryptic
47 Hybrids methodology may be a potential tool in the improvement of species that present the mixed-type
48 reproductive system, such as castor bean (*Ricinus communis* L.), for example, in reason of what these
49 species endogamic depression suggested by successive self-fertilizations is insipient [6].

Comment [DA2]: Please rephrase this sentence for clarity

50
51 Thus, the present work had the objective of analyzing the responses of castor bean hybrids produced by
52 the conventional method, in which the strains are extracted by the "Standard" method, with those of the
53 Cryptic Hybrids method.

54 55 2. MATERIALS AND METHODS

56 57 2.1. Materials

58
59 In this work, experiments were performed to verify the agronomic traits of grain productivity, oil content, oil
60 productivity and plant height of 24 inter-population hybrids of castor bean among which and of these, 12
61 hybrids were conventionally produced by the use of lines extracted by the method of "Standard"
62 method and remaining 12 hybrids by the method of by Hybrid Cryptic method, all synthesized in the
63 Department of Plant Production, Agriculture Sector, Faculty of Agronomic Sciences of the Paulista State
64 University "Júlio de Mesquita Filho".

65
66 The lines used to make the hybrids were obtained from two populations with a broad genetic base, one
67 composed of plants F2 of commercial hybrid B-9 and the other by plants of cultivar FCA-PB. The lines
68 were isolated by conducting four cycles of self-fertilization through the respective methods, being
69 extracted thus, the female (S4) lines of the B-9 population and the male (S4) lines of the FCA-PB
70 population. The remarkable characteristics of the materials used as basic populations are low size and
71 precocity, for the lines coming from the commercial hybrid B-9 is its sexual expression, in which
72 apparently does not present the phenomenon of reversion which is, something important for the
73 maintenance of the pistils lines.

74 75 2.2. Experiments

76
77 The experiments to evaluate the grain productivity of the hybrids of the S4 x S4 crosses were developed
78 in the 2006/2007, 2007/2008 and 2008/2009 agricultural years simultaneously in two municipalities of the
79 State of São Paulo, Lins and Penápolis. The same were established in for the second harvest condition of
80 the crop, being sown in both localities in the dates of 02/20/2007, 02/19/2008 and 02/17/2009,
81 respectively. It should be noted that only from the second year of experimentation were the observations
82 made on oil content, oil productivity and plant height.

Comment [DA3]: Explain this better

83
84 The experiments were conducted in randomized block design with four replicates. In all experiments, the
85 plots were constituted by rows of 5 m in length with a spacing of 0.5 m between plants and 1.0 m

between rows, totaling a useful area of 5 m². Three seeds were sown per planting hole and, being made a thinned to one plant approximately 35 days after sowing, when one plant was left per planting hole, resulting in a total of 40 plants per plot, equivalent to 20,000 thousand plants ha⁻¹. Experimental areas were fertilized according to the cultural practicese needs and recommendations described by [7], and the cultural treatments used were the usual ones.

2.3. Data collection

For the measurement of grain productivity (PG), in kg ha⁻¹, were taken grain mass data of the peeled fruits were taken per plot, correcting them to a moisture content of 10 % and estimated for hectare. The quantification of the seed oil content (TO), in %, of the seeds, was carried out by magnetic resonance method, using a homogenized sample of 15 g of seed from each plot. Once in possession of the grain yield data and the seed oil content, the determination of the oil productivity (PO), in kg ha⁻¹, was obtained by the product of these two variables. PlantRegarding the heights of plants (AP), in cm,was the measurement was performed between the soil surface and the apex of the highest branch, with each observation coming from an average of 10 plants.

2.4. Statistical procedure

The initial statistical procedures consisted of analyzing the variance individually for each site in the respective years and then a joint analysis of variance between sites and years using the fixed model, in view of the favorable relation of the residual mean squares among the different experiments and for the comparison of means of treatments, was used the Scott-Knott test (P = 0.05).

3. RESULTS AND DISCUSSION

A joint analysis of variance between sites and years (Table 1) demonstrates non-significance of the mean square of the interaction between hybrids by sites and years., Indicating thatthat is, the materials behaved similarly for grain productivity at the two assessment sites and for the three years of experimentation, thus, it is suggested that the best performance genotypes can be indicated for cultivation in these sites.

Table 1. Jjoint analysis of variance between sites and years of cryptic and conventional hybrids in Lins-SP and Penápolis-SP, in the 2006/2007, 2007/2008 and 2008/2009 agricultural years (for grain productivity) and 2007/2008 and 2008/2009 (for oil content, oil productivity and plant height).

FV	PG ¹	TO	QM	
			PO	AP
Blocks/experiment	-----	-----	-----	-----
Sites	1099656.336*	92.452*	343466.828*	771.603ns
Years	4482033.831*	0.746ns	1954828.994*	60538.341*
Hybrids	2808954.907*	20.298*	349932.142*	5069.071*
Cryptics	2037435.556*	19.987*	206307.400*	1458.341*
Conventional	3475344.532*	21.705*	463921.654*	7371.933*
Cryptics vs Conventional	3965381.893*	8.250ns	675919.671*	19455.615*
Sites x Years	151.714ns	24.470*	15751.211ns	8216.039*
Hybrids x Sites	121697.096ns	24.343*	26577.822ns	2034.549*
Hybrids x Years	290264.213*	26.211*	104567.078*	4300.398*
Hybrids x Sites x Years	101897.901ns	24.433*	52603.182*	3598.866*
Residue	82080.511	4.90	19880.888	336.774
CV	16.49	4.76	17.39	11.84

^{1/} PG: grain productivity (kg ha⁻¹); TO: oil content (%); PO: oil productivity (kg ha⁻¹); AP: plant height (cm).

* and ns: Significant and not significant, respectively, at P = 0,05 by the test F.

Comment [DA4]: This sentence need to be rephrased.

Comment [DA5]: Please state what was used to measure the plant heights

Comment [DA6]: Since the hybrids were grown at different planting years, A Bartlett's homogeneity test need to be done to show if there is common variance before the data can be pooled together for joint analysis

Comment [DA7]: Rephrase this sentence

124 | The same analysis of joint variance **also** explaineds that the mean square of the comparison of the
 125 | different hybrid production methods is significant ($P = 0.05$) by the F test, denoting that the cryptic and
 126 | conventional hybrids have different behaviors for the productivity of grains.

127 |
 128 | **Another interestingly, and important aspect to be mentioned is that,** both the mean square of the
 129 | cryptic hybrids and **the mean square of the** conventional hybrids are significant., **I**therefore, in addition
 130 | to differing grain yields for the method, the hybrids differed within the same group of materials. The
 131 | analysis of variance only has the power to indicate the significant difference, but it is not able to report the
 132 | magnitude of the difference between the means of the hybrids., **requiring, for this, the application of tests**
 133 | **of comparison between averages.**

Comment [DA8]: Same apply here. Rephrase the sentence

Comment [DA9]: This is not clear

135 | In relation to the comparison of grain productivity means of the genotypes, it can be observed, in Table 2,
 136 | that the best performance **amongin** the three agricultural years was the conventional hybrid 10.
 137 | Nevertheless, the materials that integrate the worst grain productivity also belong to the group of
 138 | conventional hybrids. This duality, coupled with the more regular performance of cryptic hybrids (63% of
 139 | materials with productivities above the total average), justifieds why the average of conventional hybrids
 140 | **was**is lower.

141 |
 142 | **Table 2. Average of the castor beans hybrids in relation to the characteristic grain productivity (kg**
 143 | **ha⁻¹) evaluated in Lins-SP and Penápolis-SP, duringin the agricultural years of 2006/2007,**
 144 | **2007/2008 and 2008/2009 agricultural years.**

Híbrido	Safras	
	2006/2007, 2007/2008 e	2008/2009
Cryptic 01	1919.6	C
Cryptic 02	1524.3	E
Cryptic 03	2214.1	B
Cryptic 04	1767.8	D
Cryptic 05	1719.4	D
Cryptic 06	1403.9	F
Cryptic 07	1613.3	E
Cryptic 08	1589.6	E
Cryptic 09	1739.5	D
Cryptic 10	2138.0	B
Cryptic 11	2359.4	A
Cryptic 12	1.846.9	D
Conventional 01	1498.0	E
Conventional 02	1655.7	E
Conventional 03	1448.9	F
Conventional 04	1156.9	G
Conventional 05	1066.9	G
Conventional 06	1707.1	D
Conventional 07	2239.7	B
Conventional 08	1764.9	D
Conventional 09	1855.8	D
Conventional 10	2366.9	A
Conventional 11	1575.7	E
Conventional 12	1508.1	E
Method		
Cryptic	1819.6	
Conventional	1653.7	
Total	1736.7	

Comment [DA10]: ???

145 | Means followed by the same letter, in the column, did not differ significantly ($P = 0.05$) by the Scott-Knott
 146 | test.
 147 |

The best productive performance **amongi n** the three agricultural years **wasis of the** cryptic hybrids, with an average of 1,819 kg ha⁻¹ of grain mass, equivalent **to the order of 10 % more productive** than the hybrids obtained by the conventional process, which presented an average of 1,653 kg ha⁻¹ of grain mass. This superiority of the cryptic hybrids consubstantially can be based on the theoretical foundation of the method, **Ssince, for** the genotypes in question **were evaluated for**, four **evaluation** cycles **for were** **carried out of** specific combining ability. Similar results were found by [8], that stud**iedyng** the productive behavior of several maize genotypes **and**, observed that the materials coming from the process of Cryptic Hybrids, had the best results.

Comment [DA11]: Rephrase this

However, the limited use of the Cryptic Hybrid method in plant genetics breeding programs **may be due toimplies a** lack of information that allows for broader discussions., **Eespecially**, when the intention is to draw a comparative parallel with the productive potential of the conventionally synthesized hybrids. Anyway, the results of grain productivity experiments carried out in the municipalities of Lins and Penápolis, demonstrated the ability of the method to obtain superior castor beans hybrids, since the **average values of** cryptic hybrids exceeded **the means of** conventional hybrids.

Nonetheless, when the interpretation of grain productivity averages of hybrids is performed holistically, considering the reality of the available genotypes in the market and the productivity of the crop in the State of São Paulo, historically the highest averages in Brazil, both groups of materials exceeded the state average for the years of experimentation, which presented values close to 1,444 kg ha⁻¹ of grain mass [9]. **This evidence corroborates that the two populations used in this work** have good germplasm to obtain lineages, especially **that hybrids are excellent** genotypes.

Comment [DA12]: Same here. Please rephrase the sentence. Also avoid the use of long complex sentences. It usually mixed information up and make the sentence difficult to understand.

Comment [DA13]:

Comment [DA14]: Which hybrid?

In the analysis of joint variance between sites and years (Table 1) for oil content, oil production and plant height, the significance of the mean square of the interaction between hybrids by sites and years was detected, indicating that the hybrids showed no coincident behavior at the two assessment sites and / or for the two years of experimentation, **requesting that a joint analysis of variance be performed between years for each of the sites.**

Comment [DA15]: This sentence is in conflict with the above sentence that said the analysis of joint variance between sites and years (Table 1)

Comment [DA16]: Reconstruct the grammar

The analysis of joint variance between years for the municipality of Lins (Table 3), has for confirmation the significance of the mean square of the interaction between hybrids for years. This implies **in the assertion** that the hybrids diverged to the character oil content in the agricultural years, it being understood, **therefore, that** there is a need to test **the materials againmore times** for the same locality in order to have a conclusive opinion of the real potential of the same. Although there is the effect of the above-mentioned interaction, the analysis of variance describes the non-significance of the mean square of the comparison between the methods of obtaining hybrids, that is, **there is no distinction in the oil content for groups of materials.**

Comment [DA17]: Same here

Comment [DA18]: ???

Comment [DA19]: What is the implication of this

Table 3. Analysis of joint variance between years in randomized block design of the cryptic and conventional hybrids in Lins-SP and Penápolis-SP, in the agricultural years of 2007/2008 and 2008/2009.

FV	QM					
	TO ¹		PO		AP	
	Lins	Penápolis	Lins	Penápolis	Lins	Penápolis
Blocks/experiment	----	----	----	----	----	----
Years	8.335ns	16.880ns	809816.673*	1160763.532*	12075.051*	56679.329*
Hybrids	19.909*	24.732*	190019.777*	186490.187*	3670.594*	3433.026*
Cryptic	17.196*	34.439*	130229.420*	101964.752*	1387.408*	1811.527*
Conventional	24.245*	16.645*	246120.234*	245627.107*	5772.611*	4013.452*
Cryptic vs Conventional	2.0502ns	6.917ns	230608.680*	465763.847*	5663.450*	14884.829*
Hybrid x Years	24.227*	26.417*	19832.964ns	137337.296*	3075.464*	4823.800*
Residue	4.685	5.115	18398.588	21363.187	234.731	438.818
CV	4.71	4.82	17.37	17.39	9.80	13.65

^{1/} TO: oil content (%); PO: oil productivity (kg ha⁻¹); AP: plant height (cm). * and ns: Significant and not significant, respectively, (P = 0.05) for the F test.

The analysis of joint variance between years for the municipality of Lins still allows to ensure that, although there are no divergences for groups of materials, the mean squares of the cryptic and conventional hybrids are significant (P = 0.05) by the F test, soon, there are differences between genotypes within the same material group. Being necessary to apply the comparison test between the means, in order to size the difference of the genotypes (Table 4).

Comment [DA20]: Please explain how it ensure this

Table 4. Average of the castor hybrids in relation to the characteristic oil content (TO), in %, evaluated in Lins-SP and Penápolis-SP, during the agricultural years of 2007/2008 and 2008/2009.

Hybrid	Lins		Penápolis	
	Year		Year	
	2007/2008	2008/2009	2007/2008	2008/2009
Cryptic 01	48.3 A	42.7 C	45.3 B	47.3 A
Cryptic 02	45.6 B	45.2 B	46.8 B	48.0 A
Cryptic 03	43.3 C	45.2 B	51.1 A	48.8 A
Cryptic 04	46.3 A	46.0 B	46.5 B	45.0 B
Cryptic 05	47.6 A	46.6 B	45.8 B	48.0 A
Cryptic 06	45.0 B	45.6 B	50.3 A	48.7 A
Cryptic 07	45.0 B	47.5 B	51.1 A	46.7 B
Cryptic 08	46.1 A	46.9 B	48.6 B	47.8 A
Cryptic 09	49.1 A	43.9 C	48.0 B	49.5 A
Cryptic 10	44.7 B	41.1 C	42.6 C	46.2 B
Cryptic 11	50.2 A	46.9 B	40.9 C	46.4 B
Cryptic 12	48.3 A	46.2 B	46.2 B	43.7 C
Conventional 01	43.8 B	44.4 B	43.5 C	51.3 A
Conventional 02	46.8 A	45.9 B	46.2 B	48.8 A
Conventional 03	41.9 C	50.1 A	46.0 B	48.2 A
Conventional 04	45.9 A	45.5 B	47.0 B	42.8 C
Conventional 05	48.1 A	44.9 B	47.6 B	41.1 C
Conventional 06	46.4 A	49.3 A	46.5 B	46.5 B
Conventional 07	48.2 A	50.1 A	48.5 B	45.5 B
Conventional 08	46.1 A	47.5 B	47.8 B	47.0 B
Conventional 09	43.7 B	47.1 B	44.7 C	51.3 A
Conventional 10	44.2 B	41.8 C	41.8 C	46.7 B
Conventional 11	48.3 A	40.1 C	47.8 B	46.0 B
Conventional 12	43.1 C	45.4 B	47.1 B	50.5 A
Method				
Cryptic	46.6	45.3	46.9	47.2
Conventional	45.5	46.0	46.2	47.1
Average	46.1	45.7	46.6	47.2

Means followed by the same letter, in the same column, did not differ significantly (P = 0.05) by the Scott-Knott test.

The interpretation of the averages of oil content of the hybrids, in the 2007/2008 agricultural year in Lins, discriminates that the best percentage is composed of several genotypes of the different groups of materials under study. However, during when attention is extended to the 2008/2009 crop year, its verified a considered variation in the oil concentration potential of some of these hybrids. For example, the conventional hybrid 11 and the cryptic 01 if characterized in the 2007/2008 harvest because they have, statistically, the best oil contents, and for the aforementioned year of 2008/2009 their averages were the worst. Similar situation happens with the conventional hybrid 03, when suddenly it if placed between the materials of better oil content.

Comment [DA21]: ???

213 The oscillation established in the experiments conducted in Lins justifies not only the interaction between
214 hybrids for years in the specified locality, as rhetorically the interaction between hybrids by sites and
215 years. Despite this, it is not possible to categorize if only the discrepancies occurring in Lins respond for
216 the significance of the interaction of hybrids by sites and years, since remains accurate analysis of the
217 experiments installed in Penápolis.

218
219 Regarding the ponderations related to the joint analysis between years for the municipality of Penápolis
220 (Table 3), it is important to state that, similarly to the one observed for the municipality of Lins, there is
221 significance of the mean square of the interaction between hybrids for years, reaffirming, once again, the
222 disparity of the hybrids in the evaluation years. Moreover, it can be inferred that in comparison to the
223 methods of obtaining hybrids there are no significant differences for the F test ($P = 0.05$).

224
225 | Also, it is also noted that the mean squares of cryptic hybrids and that of conventional hybrids are
226 significant, that is, there are genotypes that overlap others as to the oil content in the seeds. Thus, the
227 mean of test, which enables the identification of the best performances, should be performed for each of
228 the years in the thesis (Table 4), as occurred in Lins, due to the exposure of the significance of the
229 interaction between hybrids for years.

Comment [DA22]: ?????

230
231 | Seen at exposed, of the oil content averages of hybrids evaluated in Penápolis, it is noted at the outset
232 that some genotypes have abruptly altered their performances over the years. Conventional hybrids 09
233 and 01 during the 2007/2008 crop year gave the worst averages, and in the following
234 year both appear to be leading the averages of the 24 hybrids. In addition, it is worth mentioning that
235 some materials performed similarly in the two years of evaluation in Penápolis, for in the case of the
236 cryptic hybrid 03. The homogeneous performance of the hybrids in the different agricultural years is an
237 exception for the characteristic oil content, although the cryptic hybrid 03 repeated similar indices
238 for the two Penápolis experiments, this genotype was not among the best results when evaluated in Lins.
239 In short, no genotype holds the same means in three experiments, elucidating the significance of the
240 interaction of hybrids by sites and years.

Comment [DA23]: Rephrase this

241
242 One of the possible explanations for the large variations in the data measured in experiments is based on
243 the genetic nature of the oil content character, which is classified as quantitative. Quantitative traits are
244 generally conditioned by many genes with small individual effects on the phenotype and, therefore, its
245 expression is strongly influenced by the environment. The occurrence of some specific environmental
246 stimulus, in each of the agricultural years and/or sites, may have triggered a considered expression of a
247 particular gene that until then had not found the necessary conditions for its pronouncement.

248
249 In spite of the instability verified in the behavior of the materials regarding the oil content, it is necessary
250 to show that the means of the genotypes are not at all bad, the commercial cultivars present levels very
251 close, and even lower, to the reported. According to studies by [10] and [11], the preponderant factor for
252 qualification of either genotype of castor oil is not the oil content, but rather the oil productivity, which is
253 positively correlated with grain productivity, suffering less influence of the oil content.

254
255 | As a rule, it urges to mention, subsequently, the abovementioned comments, which could not be
256 typified, surely, which genotype showed the best performance for the oil content. In this sense, it is
257 worth noting the importance attached to the parameter oil productivity, product of oil content and grain
258 yield.

259
260 On the analysis of joint variance between years for the municipality of Lins (Table 3), in relation to oil
261 productivity, one of the main records reports the non-significance of the mean square of the interaction
262 between hybrids for years, leading, of course, that the materials behaved homogeneously for the two
263 experiments conducted in that locality.

264
265 | In addition, and not least, it should be mentioned there were distinction in the performance of the two
266 types of hybrids for the characteristic oil productivity, in view of the significance of the mean square of
267 the comparison between the methods of obtaining hybrids and, still, of the existence of differences

between the genotypes of the same group of materials, because the mean squares of the cryptic and conventional hybrids are significant to the F test, requiring, therefore, the application of the test of comparison between means for the indication of the contrast between the averages of oil productivity of the hybrids, in which the best productive performance of the cryptic hybrids with an average of 815 kg.ha⁻¹ of oil was detected, while the hybrids obtained by the conventional process showed an average of 745 kg.ha⁻¹ of oil (Table 5).

Comment [DA24]: This is a very complex sentence. Please slip it to simple sentences

Table 5. Average of the castor hybrids in relation to the characteristic oil productivity (kg ha⁻¹) evaluated in Lins-SP and Penápolis-SP, in the agricultural years of 2007/2008 and 2008/2009.

Hybrid	Lins	Penápolis	
	Year	Year	
	2007/2008 e 2008/2009	2007/2008	2008/2009
Cryptic 01	853.4 B	708.0 C	1059.8 B
Cryptic 02	647.7 C	764.4 C	817.4 C
Cryptic 03	961.4 A	1060.2 A	1266.8 A
Cryptic 04	777.0 B	1124.5 A	778.4 C
Cryptic 05	766.8 B	756.5 C	949.4 B
Cryptic 06	683.5 C	928.1 B	602.5 D
Cryptic 07	762.2 B	913.1 B	724.3 C
Cryptic 08	692.2 C	780.5 C	885.5 C
Cryptic 09	791.3 B	653.6 C	1012.5 B
Cryptic 10	940.4 A	589.1 C	1199.4 A
Cryptic 11	1084.5 A	739.4 C	1335.8 A
Cryptic 12	825.7 B	752.3 C	950.5 B
Conventional 01	701.5 C	493.4 C	820.4 C
Conventional 02	777.1 B	721.8 C	865.6 C
Conventional 03	664.5 C	623.7 C	791.4 C
Conventional 04	551.8 D	633.6 C	469.3 D
Conventional 05	468.3 D	678.5 C	436.3 D
Conventional 06	746.9 B	822.0 B	936.3 B
Conventional 07	1098.2 A	912.8 B	1165.4 A
Conventional 08	781.3 B	600.5 C	1035.5 B
Conventional 09	774.4 B	1030.2 A	1009.3 B
Conventional 10	1026.6 A	871.0 B	1219.4 A
Conventional 11	697.1 C	544.6 C	825.5 C
Conventional 12	663.6 C	602.8 C	879.4 C
Method			
Cryptic	815.3	814.1	965.2
Conventional	745.9	711.2	871.1
Average	780.6	762.7	918.2

Means followed by the same letter, in the same column, did not differ significantly (P = 0.05) by the Scott-Knott test.

The **description of the hybrids** oil productivity **averages of the hybrids** evaluated in Lins (Table 5), reveals that the oil productivity character is highly influenced by grain productivity. **The result shows that hybrids with the lowest, mean for since the materials whose average of oil productivity also gave the least grain yields which was** classified as the worst among the 24 hybrids **are the same ones that hold the worst grain yields**. Considering the cryptic hybrids 11, 03 and 10 and the conventional 07 and 10 genotypes with high potentials of cultivation in the **is** locality, unlike conventional hybrids 04 and 05.

290 | In summary, the cryptic hybrids **had represent** 66 % of the materials that are above the average of oil
291 | productivities for the municipality of Lins, reflecting the excellent perspective of the use of this method of
292 | obtaining hybrids in mixed species breeding programs.

Comment [DA25]: This sentence is not clear

293 |
294 | Regarding the pertinent arguments for analysis of joint variance between years for the municipality of
295 | Penápolis (Table 3), is certified sure that, unlike for Lins, there is a significance of the mean square of the
296 | interaction between hybrids for years, so, the hybrids differentiated in the agricultural years of
297 | experimentation in that locality for the characteristic oil productivity.

Comment [DA26]: Same here

298 |
299 | **There Still considering the same analysis of variance, it is possible to perceive the was**
300 | **significancesignificance difference in**of the mean square of the comparison of the different methods of
301 | obtaining hybrids., **Similarly tothat is, just like what tohappened in** Lins, the oil productivity performance
302 | **wasis among the hybrids different between the groups of materials.** In the locality in question,
303 | considering the two years, the cryptic hybrids **weare** on average 11 % more productive, totaling 889 kg
304 | ha⁻¹ oil, than conventional hybrids, with 791 kg ha⁻¹ oil (Table 5).

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305 |
306 | **CAs a consequentlly,ce of the exposure of the the** average **of the hybrids** oil productivity **of the hybrids,**
307 | **it weis worth noting that these** are larger in Penápolis **when** compared to those measured in Lins. The
308 | oil productivity of the cryptic hybrids in Penápolis **wasis** approximately 8.3 % higher than those of Lins.,
309 | **for Cconventionally synthesized hybrids, the increased by is in the order of** 5.8 %.

310 |
311 | **Not unlike that found for all characters up to then,** the mean square of the cryptic hybrids as well as that
312 | of the conventional hybrids are significant **to the F test** (P = 0.05), confirming, **once again,** to have
313 | superior genotypes within the same material group. The achievement of the comparison test between
314 | means for the identification of the best genotypes, in reason of Penápolis is a critical location for the
315 | behavior of materials in the different years of experimentation (Table 3).

Comment [DA27]: Rephrase

316 |
317 | The presentation of the average oil productivity of the hybrids when evaluated in Penápolis shows that
318 | the agricultural year preeminently responsible for the interaction between hybrids by sites and years is
319 | that of 2007/2008, because it is in the experiment of that year that there are the most sensible variations
320 | in the performances of the hybrids. Aside from this, the behavior of the 24 genotypes in the 2008/2009
321 | experiment is very consistent with that reported for the Lins locality. These statements can be exemplified
322 | by comparing the means of the cryptic hybrid 10 and 11, which have the worst oil productivity averages in
323 | the year 2007/2008 in Penápolis and the best for the two years of evaluation in Lins and in the 2008/2009
324 | agricultural year in Penápolis.

325 |
326 | Despite the irregular behavior of the materials between the agricultural years in Penápolis, it **wasis**
327 | emphasized that hybrids obtained by the Cryptic Hybrids method presented better oil productivity not only
328 | in the general averages, but also in each of the evaluation years, **including in the year** determining the
329 | **theirpresence of the** interaction between hybrids by sites and years. In addition, cryptic hybrid 03 **wasis**
330 | the only material characterized with the best average productivity in all experiments.

331 |
332 | Due to the pioneering nature of the work proposal, as commented before, there is some restriction in the
333 | deepening of the discussions, however, it is undeniable that the results obtained for the characteristic oil
334 | productivity, even with the exceptionality of an agricultural year in Penápolis, are hopeful and suggest the
335 | possibility of diffusion of the method of the Cryptic Hybrids, considering the superiority of the genotypes
336 | synthesized and time savings in hybrids production.

337 |
338 | **The analysis of joint variance among the hybrids for the years in the municipality of Lins (Table 3),**
339 | **detected the significance of the mean square of the interaction between hybrids for years. Thus,**
340 | **according to the already verified in that site for the characteristic content of oil, the height averages of the**
341 | **hybrids are unequal, statistically, in the evaluation years.**

Comment [DA28]: rephrase

In order to understand the discrepancies in the size of the genotypes, the test of comparison between averages was carried out in each of the years of experimentation, as shown in Table 6, due to the significance of the interaction between hybrids by years.

Comment [DA29]: What is the name of the test

Table 6. Average of castor hybrids in relation to the characteristic height of plants (cm) evaluated in Lins-SP and Penápolis-SP, in the agricultural years of 2007/2008 and 2008/2009.

Hybrid	Lins		Penápolis	
	Year		Year	
	2007/2008	2008/2009	2007/2008	2008/2009
Cryptic 01	200.6 B	163.0 A	97.8 D	211.3 A
Cryptic 02	116.0 D	165.3 A	184.7 A	190.1 A
Cryptic 03	189.5 B	165.6 A	159.8 B	174.4 B
Cryptic 04	111.8 D	163.6 A	113.0 C	163.6 B
Cryptic 05	155.8 C	170.5 A	177.3 A	162.2 B
Cryptic 06	154.7 C	167.0 A	112.7 C	193.6 A
Cryptic 07	155.7 C	173.6 A	158.6 B	172.2 B
Cryptic 08	172.5 C	171.6 A	106.6 C	182.6 B
Cryptic 09	165.9 C	161.6 A	204.7 A	170.7 B
Cryptic 10	152.0 C	151.3 A	158.9 B	173.6 B
Cryptic 11	156.0 C	171.2 A	133.4 C	176.4 B
Cryptic 12	156.2 C	169.0 A	152.1 B	162.7 B
Conventional 01	176.4 B	163.1 A	159.6 B	193.1 A
Conventional 02	165.7 C	168.1 A	82.9 D	213.9 A
Conventional 03	181.3 B	168.2 A	123.2 C	206.1 A
Conventional 04	141.7 C	166.6 A	141.2 B	214.4 A
Conventional 05	152.2 C	164.5 A	156.1 B	167.3 B
Conventional 06	68.9 E	162.3 A	125.6 C	159.8 B
Conventional 07	58.2 E	163.4 A	117.2 C	150.0 C
Conventional 08	67.9 E	158.5 A	78.5 D	139.4 C
Conventional 09	159.6 C	172.0 A	113.3 C	138.2 C
Conventional 10	146.0 C	146.2 A	74.6 D	161.3 B
Conventional 11	129.1 C	147.7 A	154.9 B	106.4 D
Conventional 12	255.6 A	166.1 A	182.7 A	110.8 D
Method				
Cryptic	157.2	166.1	146.6	177.8
Conventional	139.4	162.2	125.8	163.4
Average	148.3	164.2	136.2	170.6

Means followed by the same letter, in the same column, did not differ significantly ($P = 0.05$) by the Scott-Knott test.

The exposure of the height average of the castor hybrids when evaluated in Lins which indicates that the 2008/2009 gave a gricultural year was the one that provided the most homogeneous results for the character. Since, on average, all 24 genotypes presented the same statistical value for the mean test.

Considering that the low size of the plants is of great importance when one glimpses the mechanized harvest of the castor bean crop, it is necessary to consider the size of those materials that obtained the best grain and oil productivity averages for the experiments conducted in Lins. Among these, highlights are given to conventional hybrids 07 and 10, which have the smallest height, not only among the materials of better productivity, but also among all 24 genotypes, for the respective agricultural years, and to the cryptic hybrid 10, smaller stature of the cryptic hybrids of better productivity in the two years of experimentation and smaller stature of the cryptic hybrids in the agricultural year of 2008/2009.

This observation about the height of the genotypes of better productive performance is very interesting, because several scientific studies, such as [12] and [13], report the presence of a positive correlation between height of castor bean plants and yield, that is, the highest productivities belong to the higher

367 stature materials, and, apparently, this can not be affirmed for the evaluations carried out in Lins.
368 However, if we restrict the reasoning only for the means of the groups of materials, in fact, the cryptic
369 hybrids are the genotypes of greater stature and also those of greater productivities.

370
371 It is useful to mention that, according to the classification scale of the castor bean size proposed by [14],
372 the material of low size is one that does not exceed 150 cm in height and the medium sized one with
373 height between 150 cm and 200 cm. Therefore, only the average of conventional hybrids in the 2007/08
374 crop year can be typified as low stature. The height of plants, as well as the other agronomic traits studied
375 in this work, is genetically controlled by several genes, quantitative nature, and its expression has strong
376 influence of the environment. This helps to explain the reason of certain genotypes, such as conventional
377 hybrids 06, 08 and 07, showed height variation between the years of experimentation.

Comment [DA30]: This needs reconstruction

378
379 In relation to the analysis of joint variance between the hybrids and the years for the municipality of
380 Penápolis (Table 3), it is perceived, again, that genotypes also expressed changes in plant height
381 between one year and another of experimentation, because there is significance of the mean square of
382 the interaction between hybrids for years.

383
384 In addition, it wasthere is evidence that both genotypes and groups of materials have are distinct plant
385 height for the characteristic height of plants, since the mean square of the comparison between
386 methods of obtaining hybrids is significant to the F test ($P = 0.05$). In Penápolis, andsimilar to that in
387 Lins, the average squares of the cryptic hybrids and the conventional hybrids are significant, so there are
388 different sizes of height within the same group of materials.

389
390 In Penápolis, similar to what happened in Lins, the mean squares of cryptic hybrids and conventional
391 hybrids are significant, so there are different sizes of height within the same group of materials. In order to
392 identify these genotypes of higher and lower height, such as observing the differences in height of
393 genotypes between the years of experimentation, the test of comparison between means was applied, in
394 which in the evaluation conditions of Penápolis, the conventional hybrids reaffirmed the status of smaller
395 genotypes when they reached, on average, the height of 144 cm, while the cryptic hybrids were 162 cm
396 (Table 6).

Comment [DA31]: When there is significant difference between or among treatments, the science and logic behind it has to been well explained in line with what other researchers have done. This has not been well explained

Comment [DA32]: Same here

397
398 Attaining for the means of the 24 genotypes in the respective years of experimentation in Penápolis, it is
399 easy to understand the reasons for the significance of the interaction between hybrids for years of the
400 analysis of joint variance. Conventional hybrid 12 in the 2007/2008 crop year is classified statistically as
401 one of those higher stock materials and in the following crop year it is one of the two lowest value
402 averages. Something very similar happens with conventional hybrid 11.

Comment [DA33]: This sentence is not clear

403
404 Of those genotypes that have the best grain productivity, in Penápolis, it is highlighted, again, the
405 conventional hybrid 10, now in the agricultural year of 2007/2008, holder of the smallest average among
406 the 24 genotypes, and the conventional hybrid 07, which has the lowest height of the materials with the
407 best productive performance, in the agricultural year of 2008/2009.

408
409 In relation to the stature of the hybrids of the best averages of oil productivity in Penápolis, the lowest
410 heights are from the cryptic hybrid 04, in the 2007/08 crop year, and from the conventional hybrid 07, for
411 the 2008/2009 crop year. Having said all this, in general, for the plant height character, the conventional
412 hybrids stood out to the cryptic hybrids, having as background the importance of the low size of the plants
413 for the castor bean crop, since they have the smallest mean plant size. However, there are cryptic hybrids
414 of the same excellent productivities that also have the height classified as of low size, even though it
415 presents greater stature when compared to the conventional hybrid.

416 4. CONCLUSION

417
418 The Cryptic Hybrids method was efficient to obtain lineages and hybrids superior of castor beans when
419 compared to the standard "Standard" method.
420
421

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Comment [DA34]: This is not correct