

# The Second International Conference on Genetic Resources and Biotechnology

## Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture

Bogor, Indonesia • 24–25 May 2021

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January 2022

THE SECOND INTERNATIONAL CONFERENCE ON GENETIC RESOURCES  
AND BIOTECHNOLOGY: Harnessing Technology for Conservation and Sustainable  
Use of Genetic Resources for Food and Agriculture

# Committees: The Second International Conference on Genetic Resources and Biotechnology

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## **Preface: The Second International Conference on Genetic Resources and Biotechnology**

The Second International Conference on Genetic Resources and Biotechnology, which is the continuation of the first event held in 2018, focuses on topics related to advances in biotechnology to create more opportunities for effective conservation and sustainable utilization of genetic resources for food and agriculture. This year conference's theme is Harnessing Technology for Conservation and Sustainable Use of Genetic Resources for Food and Agriculture. The conference was organized by Indonesian Agency for Agricultural Research and Development (IAARD), Ministry of Agriculture, Indonesia, in collaboration with Indonesian Biotechnology Consortium and held on 24<sup>th</sup>-25<sup>th</sup> of May 2021 virtually due to the pandemic of COVID-19.

The conference aims to share and exchange current scientific information and technological developments on biotechnology and their applications for conservation and sustainable use of genetic, to encourage and promote quality, efficiency, and modernization of management and utilization of genetic resources, and to facilitate national and international collaboration among participants. There are five scopes discussed in this conference. They are effective management of conservation and sustainable use of genetic resources for food and agriculture, application of genomics and molecular markers for genetic resource conservation and crop adaptation to climate change, application of innovative crop improvement techniques for conservation and sustainable use of plant genetic resources for food and agriculture, plant cell and tissue culture for conservation and effective utilization of genetic resources, and the use of microbial genetic resources as biological control agents of agricultural pests and diseases, and for soil bioremediation.

Five speakers from the United States of America, Japan, India and Indonesia were invited to discuss about their expertise and knowledge on relevant subjects in the plenary sessions. This conference was attended by more than 100 participants including 75 presenters and 44 listeners worldwide. They came from diverse governmental, private, or academic institutions and also scientific communities. The presented materials have undergone peer review processes and only qualified papers were selected. Furthermore, all papers were subjected to double blind peer-review and expected to meet the scientific criteria of significance and academic excellence to be published in a conference proceedings indexed in a well-known, reputable service.

We would like to express our sincere gratitude to our speakers, presenters and all participants for their contributions in this conference. We would also like to express our appreciation for the generosity of our sponsors that support this conference: PT CropLife, PT ITS Science Indonesia, PT Fajar Mas Murni and PT Prima Instrument Analitika. Lastly, special thanks to all committee members for their exceptional work and contributions in the conference and publication.

Chair of Organizing Committee

Dr. Toto Hadiarto

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# Characterization of Plant Architecture and Yield Trait of Castor (*Ricinus communis* L.) Germplasm Suitable for Mechanical Harvesting

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**Abstract.** Characterization of castor (*Ricinus communis* L.) germplasm on plant architecture and yield trait is important for breeding program of dwarf variety with high yield, suitable for mechanical harvesting. This study aimed to conduct complete characterization of castor germplasm on plant stature and seed and oil yield trait. The materials used in this study were 29 castor accessions. The accessions were planted and observed for plant architecture and yield traits. The results showed that the germplasm collections had variation on plant height, i.e. normal, semidwarf, and dwarf, with internode length on the main stem ranged from 3.79 to 9.64 cm and number of branches from 3 to 15. The length of fruit raceme of main stem varied from 21 to 95 cm and the seed weight per raceme ranged from 6.85 to 124.83 g. Oil content ranged from 24.23 to 50.37%. There were positive correlation between (p-value = 0.05) the yield trait and its component. However, only fruit number per raceme that had direct effect. Castor accessions 18A and 70B had characters dwarf, low number of branch, long fruit raceme, high seed yield, and oil content. These accessions could be utilized as genetic material potential for new castor plant variety suitable for mechanical harvesting.

## INTRODUCTION

Castor (*Ricinus communis* L.) plant is one of nonedible oilseed crop for industrial purposes. Castor is belonging to Euphorbiaceae and produced widely known castor oil that is used as a source for cosmetics, pharmaceutical, dye and paint industry, lubricant and brake fluid, and biofuel [1]. The world production is still low compared to its demand. The low of the world supply is due to the plantation scale is still not fully mechanized because of the nature habit of castor as a perennial plant [2].

Castor is believed to be originated from Eastern Africa because the available of castor with wild morphological features, such as extremely small seed, stress/disease resistance, and perennial and woody type phenotype [3]. Because of its high economic value, castor is widely cultivated in tropical, subtropical, and temperate regions, including India, China, and Brazil [4]. Wild castor cultivated during ancient times was slowly changed into cultivated form that had desirable traits, such as non-shattering, early maturity, bold seed, high oil content, and tolerance to biotic and abiotic stresses [5]. Breeding efforts further improved seed yield, oil content, and plant architecture suitable for mechanical harvesting and resistance to pest and disease [2]. Castor germplasm collections in the world cover diverse morphological variations, including variations in plant height, branching, stem color, leaf size, waxy coating, length, size and compactness of raceme, pedicle length, and size and shape of capsule and seed [5]. Likewise in the world, Indonesia also has castor collections that has variation in morphological characters as well as other characters, such as resistance to pest, flowering time, and seed size and weight [6, 7].

Castor growth habit as a perennial allow it to grow as indeterminate plant that has 3–4 m height, keep produced branch and raceme that has not uniform maturity, therefore, make the harvesting process is laborious and costly [8]. The castor varieties that has been released in the world include normal type, dwarf type, and hybrid. The first attempt in castor breeding was developing castor with early maturity, but still less productive, very tall and less

suitable to combine harvesting. Later, USA created Hale variety that has dwarf internode type and can enhance castor yield [9]. Dwarf hybrid variety with ideal type that suitable for mechanical harvesting has characters include dwarf internode, non or less branching, erect stem, and long primary raceme [10]. Although some released varieties are already suited for mechanical harvesting and been used widely in the major producing countries [11–13], it is necessary to have range of cultivars adapted to many production environments and every cropping system [2].

Breeding programs for varieties with desirable characters need germplasm collection as source material. Indonesia has collection of castor germplasm with high morphological variation. As for now Indonesia still does not have hybrid dwarf variety that suitable for mechanical harvesting. Castor varieties developed in Indonesia, such as ASB 81 and Asembagus 119 Agribun, are normal type that have high yield, 200–350 cm in height, many branches, and the harvest time is conducted 7 to 8 times in one year because the new raceme is continuously emerge so it is hard to do harvesting mechanically [6;14]. These normal types are also suitable for intercropping with food crops, such as mung bean and sesame [15]. The developing of new plant variety with dwarf type suitable for mechanical harvesting could enhance the increase productivity of seed yield and broaden the range of cultivars that could be choose by the farmers and industries. The breeding program should be initiated by producing information of germplasm collection for utilizing it in process of developing new variety with desirable characters. Therefore, this study aimed to characterize the castor germplasm for plant architecture and yield trait in order to use as parents to develop new hybrid variety.

## MATERIALS AND METHODS

The study was conducted in Asembagus Experimental Station, Indonesian Sweetener and Fiber Crops Research Institute (ISFCRI) located in Situbondo, East Java, Indonesia (07°39'S, 114°12'E; 10 m asl) from January to December 2018. The plant materials used were 29 castor germplasm from ISFCRI collection. The accessions were planted in a plot without experimental design. Every accession were planted in a plot of 10 m × 10 m that consisted of 30 plants. The accessions were planted in a row with plant spacing 2 m × 2 m. Seeds were planted in a hole and covered with soil. Fertilizer applied was 75 kg/ha N + 30 kg/ha P<sub>2</sub>O<sub>5</sub>, and 30 kg/ha K<sub>2</sub>. The fertilizer was applied two times (3 weeks and 7–8 weeks after planting). The pest, disease, and weed control were applied as the condition in the field. The irrigation was needed during the early growth period (up to 2 months after planting) and was supplied by rainfall.

**TABLE 1.** List of castor accessions from Indonesian Sweetener and Fiber Crops Research Institute collection and their origin.

No.	Accession	Origin	No.	Accession	Origin
1	Rc 1M	East Java	16	Rc 80	East Java
2	Rc 7	East Java	17	Rc 93	East Java
3	Rc 18A	East Java	18	Rc 95	East Java
4	Rc 23	East Java	19	Rc 97	East Java
5	Rc 29A	East Java	20	Rc 102	East Java
6	Rc 30A	East Java	21	Rc 177B	Central Java
7	Rc 42	East Java	22	Rc 177C	Central Java
8	Rc 42B	East Java	23	Rc 177D	Central Java
9	Rc 52	East Java	24	Rc 182	West Nusa Tenggara
10	Rc 52B	East Java	25	Rc 183	East Nusa Tenggara
11	Rc 53	East Java	26	Rc 203	West Java
12	Rc 58A	East Java	27	Rc 207A	Central Java
13	Rc 59A	East Java	28	Rc 229A	Bali
14	Rc70B	East Java	29	Rc 229B	Bali
15	Rc76	East Java			

## Observation and Data Analysis

Data were collected on 16 quantitative traits of plant architecture and yield including plant height (from ground to the base of the primary raceme), canopy width, nodes number, node length average, branch number, petiole length, leaf blade length, leaf blade width, leaf blade lobe, flowering time, fruit raceme length, fruit number per raceme, seed weight/plant, seed length, seed width, and oil content [16]. The data were collected from five plants per accession, except for flowering time were measured on the population basis. The plant architecture and leaf characteristics were measured at first flowering time stage. Correlation analysis were conducted using Hmisc package [17] and correlation matrix were drawn using Corrplot package [18]. Path analysis were conducted using Lavaan package [19]. The analysis was conducted using R 3.6.3 [20].

## RESULTS AND DISCUSSIONS

### Castor Plant Architecture and Yield Traits

**TABLE 2.** Plant architecture characteristics of 29 castor accessions from Indonesian Sweetener and Fiber Crops Research Institute collection.

Accession	Plant height (cm)	Canopy width (cm)	Nodes number	Node length average (cm)	Branch number	Petiole length (cm)	Leaf blade length (cm)	Leaf blade width (cm)	Leaf blade lobe (cm)
Rc 1M	103.86	133.38	13.60	7.64	5	30.66	30.23	48.48	18.79
Rc 7	119.30	177.80	14.80	8.06	5	40.40	37.88	63.09	22.33
Rc 18A	89.38	158.60	12.20	7.33	3	46.37	33.51	53.71	19.28
Rc 23	113.74	148.56	14.60	7.79	4	39.73	32.32	52.87	18.27
Rc 29A	105.96	139.20	15.20	6.97	8	38.47	33.59	55.55	19.69
Rc 30A	117.80	152.60	19.80	5.95	6	34.27	33.67	56.13	19.73
Rc 42	107.54	146.60	16.60	6.48	10	36.07	31.80	50.50	18.89
Rc 42B	104.00	143.00	12.50	8.32	10	41.83	27.50	47.17	17.33
Rc 52	102.20	170.40	17.60	5.81	12	45.00	31.77	52.64	15.47
Rc 52B	104.60	163.00	15.40	6.79	14	41.13	37.80	61.01	21.62
Rc 53	128.60	162.80	19.20	6.69	15	37.30	33.95	56.20	21.43
Rc 58A	126.80	160.00	15.20	8.34	13	41.07	38.31	62.70	23.13
Rc 59A	105.80	153.00	14.00	7.56	14	41.07	32.83	54.60	19.53
Rc 70B	87.60	111.20	15.00	5.84	10	23.40	24.93	41.80	14.73
Rc 76	82.20	115.20	10.80	7.61	10	29.50	25.33	41.70	15.50
Rc 80	80.80	158.80	13.00	6.22	8	37.93	34.81	56.33	19.70
Rc 93	148.60	169.20	15.40	9.65	8	44.07	39.60	65.60	25.21
Rc 95	99.80	148.50	11.80	8.46	8	42.75	34.32	56.27	22.07
Rc 97	110.20	137.80	12.60	8.75	8	40.83	29.53	49.39	18.35
Rc 102	115.90	167.40	16.80	6.90	8	34.33	33.33	54.87	22.27
Rc 177B	123.20	187.80	19.40	6.35	13	39.00	39.13	60.60	24.73
Rc 177C	104.80	146.00	16.60	6.31	12	30.07	30.20	51.87	19.40
Rc 177D	74.75	157.25	19.75	3.78	14	35.00	33.96	53.33	18.58
Rc 182	138.90	160.00	18.20	7.63	4	34.14	35.10	60.57	23.10
Rc 183	104.20	147.40	16.40	6.35	6	27.07	29.77	48.70	18.67
Rc 203	85.30	136.60	17.80	4.79	8	28.13	32.57	52.87	19.60
Rc 207A	106.40	145.20	13.00	8.18	10	38.73	32.82	51.23	19.03
Rc 229A	85.20	148.00	13.20	6.45	8	37.93	29.93	49.68	17.41
Rc 229B	87.00	144.80	13.20	6.60	8	40.87	32.17	52.90	19.43
<b>Mean</b>	<b>105.67</b>	<b>151.38</b>	<b>15.29</b>	<b>7.02</b>	<b>9.03</b>	<b>37.14</b>	<b>32.85</b>	<b>53.87</b>	<b>19.77</b>
<b>SD</b>	<b>17.64</b>	<b>16.44</b>	<b>2.49</b>	<b>0.23</b>	<b>3.33</b>	<b>1.05</b>	<b>3.65</b>	<b>5.76</b>	<b>2.57</b>
<b>CV (%)</b>	<b>16.69</b>	<b>10.86</b>	<b>16.62</b>	<b>1.23</b>	<b>36.89</b>	<b>5.68</b>	<b>11.12</b>	<b>10.68</b>	<b>12.97</b>

The quantitative characters on plant architecture and leaf were shown in Table 2. The plant height ranged from 74.75 to 148.6 cm. The canopy width had mean value of 151.38 cm and did not have much variation (coefficient variation/CV = 10.86%). The average of nodes number and the node length of main stem showed the similar CV value ranged from 10.8 to 19.8 and 3.78 to 9.65 cm, respectively. The branch number had the highest CV value or large variation ranged from 3 to 15 branches. The plant architecture in castor plant is a key trait for breeding for dwarf variety. According to Severino *et al.* [2], dwarf variety that suitable for mechanical harvesting has plant height less than 100 cm, erect stem, and less or no branch. In this study, we found nine accessions that have plant height less than 100 cm (77–90 cm).

Castor leaves are palmate with 7–11 lobes and have long petioles [21]. The leaves size in this study ranged from 24.93 to 39.6 cm in length and 41.7 to 65.6 cm in width. Petiole length ranged from 23.4 to 46.37 cm and leaf lobe length had mean value of 19.77 cm. The long petiole thought to restrict the adoption of high plant density [21]. Dwarf variety is planted with high plant density to maximize the harvested seed yield [12].

The yield traits of 29 castor accessions are shown in Table 3. The flowering time varied from 43 to 77.2 days with mean value 62.04 days. Fruit raceme length ranged from 21 to 95 cm with CV 37.43%. Fruit number per raceme had large variation with CV value of 51% ranged from 13 to 120. The seed weight per plant had mean value of 242.3 g and CV value of 43.42%. The seed size ranged from 10.86 to 16.36 cm in length and from 6.6 to 10.76 cm in width. Oil content varied from 24.23 to 50.37 %.

**TABLE 3.** Yield and yield trait components of 29 castor accessions from Indonesian Sweetener and Fiber Crops Research Institute collection.

Accession	Flowering time (days)	Fruit raceme length (cm)	Fruit number per raceme	Seed weight per plant (g)	Seed length (mm)	Seed width (mm)	Oil content (%)
Rc 1M	57.6	67	60	62.42	14.55	8.57	42.56
Rc 7	67.4	34	58	68.60	15.61	9.95	43.68
Rc 18A	50.4	56	66	84.65	15.22	10.76	50.13
Rc 23	58.4	95	99	119.92	14.60	9.31	48.95
Rc 29A	63.8	51	54	60.79	14.26	8.82	42.91
Rc 30A	70.2	51	58	68.32	12.55	7.59	44.73
Rc 42	60.0	74	114	87.72	12.96	7.98	28.90
Rc 42B	58.5	46	54	36.17	12.73	8.77	38.67
Rc 52	62.6	90	120	124.83	14.90	8.85	30.37
Rc 52B	54.6	37	75	85.50	13.90	8.24	24.23
Rc 53	62.0	65	90	74.39	13.47	8.47	29.90
Rc 58A	62.0	45	60	68.40	13.59	8.18	35.26
Rc 59A	47.2	67	48	55.40	14.66	9.05	32.25
Rc 70B	77.2	81	66	76.18	14.13	9.76	50.37
Rc 76	60.2	42	34	40.21	15.17	9.13	47.33
Rc 80	58.8	27	14	14.56	14.94	8.8	44.94
Rc 93	62.4	58	36	47.20	15.29	8.85	44.99
Rc 95	48.2	42.5	34	46.51	16.36	10.58	33.12
Rc 97	43.0	77	74	73.82	13.27	8.34	40.66
Rc 102	71.2	56	39	46.13	15.72	9.58	47.74
Rc 177B	72.4	36.5	90	71.82	13.76	8.02	45.11
Rc 177C	69.0	83	74	41.12	11.50	6.77	29.56
Rc 177D	71.75	55	39	22.23	11.77	7.23	35.07
Rc 182	72.4	52	68	79.50	13.98	8.93	29.47
Rc 183	69.0	42	28	17.56	11.18	7.09	35.53
Rc 203	71.0	37	31	32.69	13.12	7.15	30.27
Rc 207A	54.6	28	15	17.10	15.09	8.71	27.53
Rc 229A	61.6	21	13	6.85	11.04	6.79	40.97
Rc 229B	61.8	26	19	9.21	10.86	6.6	32.64
<b>Mean</b>	<b>62.04</b>	<b>53.17</b>	<b>56.21</b>	<b>242.2</b>	<b>13.80</b>	<b>8.51</b>	<b>38.20</b>
<b>SD</b>	<b>8.42</b>	<b>19.20</b>	<b>28.72</b>	<b>105.3</b>	<b>1.50</b>	<b>1.08</b>	<b>7.80</b>
<b>CV (%)</b>	<b>13.56</b>	<b>37.43</b>	<b>51.10</b>	<b>42.42</b>	<b>10.88</b>	<b>12.73</b>	<b>20.43</b>

The accessions with short character (less than 1.5 m), length of primary raceme between more than 40 cm, number of capsules per raceme >60, less than 150 days of harvesting, erect plant, and non-shattering fruits are searched for breeding programs for dwarf variety with high yield suitable for mechanical harvesting [2, 12]. In this study, we found nine accessions that had height less than 1 m. There were Rc 18A, Rc 70B, Rc 76, Rc 80, Rc 95, Rc 177D, Rc 203, Rc 229A, and Rc 229B. Rc 56, Rc 76, Rc 76, Rc 95, and Rc 177D had fruit raceme that longer than 40 cm, even could reach 81 cm (Rc 70B). However, this accession only had 31% of fruit part compare to the total raceme length (Fig. 1). Merkouropoulos *et al.* [10] mentioned the length of primary raceme of four dwarf hybrids of their study ranged between 45–70 cm.

Castor plant suitable for mechanical harvesting also had reduced number of branch and total raceme per plant. The present of many branches and indeterminate growth of castor plant make the harvest become difficult and laborious [8, 10]. In this study, accession Rc 229A and Rc 229B had plant height lower than 100 cm, however this accession had high number of branch (eight branches), with architecture that make it difficult to harvest manually (Fig. 2). Merkouropoulos *et al.* [10] categorized dwarf hybrid castor has two to five secondary branches. Baldanzi and Pugliesi [22] conducted a selection to obtain unbranched castor through recurrent selection for 5 years. Furthermore, as it is shown in Fig. 2, the panicle shape of Rc 229A is globose, that lead to rounded fruit raceme shape. This characteristic yield only low number of fruits per raceme (Table 2). Rodrigues da Silva *et al.* [23] mentioned three types of fruit raceme shapes, i.e. globose/rounded, cylindrical, and conical. In our study, we found 8 accessions that had round fruit racemes, 13 accessions with cylindrical shapes, and 8 accessions with conical shapes. Accessions that had cylindrical and conical shape in this study tend to had longer raceme and more fruit number per raceme than the accessions with round shape.

Among the accessions with short character, there were two accessions that had raceme more than 40 cm and fruit number more than 60. They were Rc 18A and Rc 70B. These accessions also had high oil content, i.e. 50.13 and 50.37%, respectively. These two accessions could be the candidate for dwarf variety with high yield and oil content. In addition, the accessions that had normal height could be utilized for donor parent in hybridization program for introgression of desirable trait. For example, Rc 42 and Rc 52B, that had height more than 100 cm, had fruit raceme that could reach 74 and 90 cm, and yield 114 and 120 fruit number per raceme, respectively.



**FIGURE 1.** The performance of castor plant architecture of Rc 70B accession. (a) Plant height less than 100 cm (up to distal of first raceme). (b) Fruit raceme 81 cm in length. (c) Fruit part (only 31% of total raceme). (d) Male flower.



Correlation analysis is insufficient to explain true relationship between the traits [25], therefore, we conducted path analysis. The path analysis result showed that even though the component of yield trait had significant correlation with yield trait, only fruit number per raceme that had direct effect to seed weight per plant (Table 4). Hence, this trait may directly contribute to improvement of seed yield of castor. The raceme length could be increase the seed weight indirectly from the fruit number per raceme because indirect effect gives influence to a character through other characters [26].

**TABLE 4.** Estimation of direct and indirect effect of traits to yield trait in castor accessions.

Character	Estimate	Standard error	Z-score	P(> z )
<b>Seed weight per plant</b>				
Fruit number per raceme	0.843	0.063	13.333	0.000
Raceme length	-0.028	0.092	-0.300	0.764
Plant height	0.203	0.137	1.479	0.139
Flowering Time	-0.363	0.237	-1.530	0.126
<b>Raceme length</b>				
Plant height	0.394	0.245	1.606	0.108
Flowering time	-0.176	0.422	-0.418	0.676

## CONCLUSION

The characterization of 29 castor accessions could be use as information for selection in breeding program for create dwarf variety suitable for mechanical harvesting with high seed yield. There were nine accessions that had short stature and among them Rc 18 and Rc 70B had raceme length and fruit number suitable for high yield dwarf variety. All component of yield trait had positive correlation with seed weight per plant, however, only fruit number per raceme that had direct effect. This information is necessary for selection and breeding for dwarf variety with high yield suitable for mechanical harvesting.

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