Industrial Crops and Products 31 (2010) 139–144

Contents lists available at ScienceDirect

Industrial Crops and Products

journal homepage: www.elsevier.com/locate/indcrop

Extra-early maturing germplasm for utilization in castor improvement

K. Anjani*

Directorate of Oilseeds Research, Rajendranagarr, Hyderabad 500030, India

ARTICLE INFO

Article history:
Received 22 July 2009
Received in revised form
18 September 2009
Accepted 22 September 2009

Keywords:
Castor
Correlation
Extra-early maturity
Diversity
Variance component

ABSTRACT

Diverse sources of extra-earliness are required for breeding high yielding extra-early castor (*Ricinus communis* L.) cultivars. Twenty-three extra-early accessions and four checks were evaluated from 2003–2004 to 2007–2008. Variance components for 14 traits and correlation coefficients were estimated. Significant genotypic differences were observed for these traits. Number of main stem nodes, days to 50% flowering and days to maturity exhibited high σ^2_g and non-significant $\sigma^2_{g\times e}$ interactions. They showed significant high positive correlations with each other and very low associations with yield and its components. Yield exhibited moderate associations with its components except 100-seed weight. Cluster analysis grouped the entries into four groups. All 23 accessions exhibited stable performance for extra-early maturity. Accessions were identified for high oil content, high yield and high per day productivity. The promising accessions identified and the information generated would be useful for breeding extra-early cultivars as well to study inheritance of extra-earliness.

1. Introduction

Castor (*Ricinus communis* L.) is an important industrial oilseed crop. Its seed oil has more than 400 industrial uses ranging from medicines to biodiesel production (Devendra and Raghavan, 1978; Bhardwaj et al., 1996). India, Brazil and China are the major castor producing countries. Castor is generally grown as an annual crop even though it is essentially a perennial shrub and indeterminate in fruiting habit. Castor cultivars are classified as early (120–140 days), medium (140–160 days) and late (>160 days) maturity types based on duration taken from planting to maturity of primary raceme (Weiss, 1983; Atsman, 1989). In India, it is mainly grown as a six–eight months duration crop and planting is generally taken up between June and July. Harvesting is done in four pickings from 120 to 210 days after planting with one-month interval between pickings. About 80% of castor production in India comes from rainfed areas (Damodaram and Hegde, 2007). Moisture stress is the major yield limiting factor in castor. The crop generally undergoes moisture stress at around 60–65 days after planting that coincides with flowering and capsule formation stages. Extra-early maturing (<100 days) cultivars would enable the crop to grow and set seeds before moisture stress sets in. They would also reduce production cost and facilitate expansion of the crop to newer areas by fitting into multiple cropping schemes of the areas. In the past, most castor breeding programmes focused primarily on developing high yielding medium duration cultivars. Extra-early maturing cultivars are not yet available. Development of high yielding extra-early cultivars is a challenge as early flowering habit is generally associated with low productivity. Diverse extra-early maturing sources are primarily required for breeding high yielding extra-early cultivars. At the Directorate of Oilseeds Research, Hyderabad, India, 23 extra-early accessions which mature in less than 100 days were developed. Information on genetic divergence of these extra-early accessions, their yield performance and stability for extra-earliness are needed to promote their use in developing high yielding extra-early cultivars.

In the present study, 23 extra-early accessions were evaluated along with four checks of different maturity durations in five contiguous years (2003–2007). Yield performance of 23 extra-early accessions over years and genetic divergence in these accessions were assessed. In addition, G × E interaction, variance components and correlations among 14 quantitative traits were estimated. The information generated should be useful to breeders in selection of appropriate extra-early parental lines and to fine-tune the breeding programmes aimed at development of extra-early cultivars.

2. Material and methods

Twenty-three extra-early accessions along with four checks *viz.*, 'Sowbhagya', '48-1', 'DCS-9' and 'GCH-4' were planted between second and third week of June in 2003, 2004, 2005, 2006 and 2007 in a randomized complete-block design with three replications under rainfed conditions in Alfisol at the Directorate of Oilseeds Research, Hyderabad, India (17.366°N and 78.478°E). The checks used are

* Tel.: +91 040 24015345; fax: +91 040 24017969.
E-mail address: anjani_kammili@rediffmail.com.

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doi:10.1016/j.indcrop.2009.09.016

Table 1
Morphological traits and country of origin of parental sources of extra-early accessions and checks.

Accession	Country of origin and identity number of parental sources and checks	Stem colour	Bloom	Capsule size and nature	Capsule dehiscence	Seed size, shape and colour
RG 155	Former USSR (EC154818)	Purple	0	B, SP	NDC	B, E, DRC
RG 211	Former USSR (EC170488-1)	Purple	0	M, SP	PDC	S, E, BR
RG 30	Former USSR (EC170486)	Purple	0	M, SP	NDC	S, O, DRC
RG 148	Former USSR (EC153579)	Green	2	M, SP	NDC	B, E, BR
RG 210	Former USSR (EC170487)	Red	1	M, SP	NDC	S, O, DRC
RG 26	USA (EC169671-1)	Green	0	M, NSP	NDC	S, E, BR
RG 24	USA (EC169662)	Purple	0	S, SP	PDC	S, E, DRC
RG 28	USA (EC169689)	Purple	0	B, SP	PDC	S, E, DRC
RG 190	USA (EC169666)	Green	2	M, NSP	NDC	B, E, BR
RG 25	USA (EC169671)	Green	0	M, SP	NDC	S, O, BR
RG 187	USA (EC169663)	Green	1	B, SP	NDC	S, E, DRC
RG 188	USA (EC169664-1)	Green	1	S, SP	NDC	S, E, BR
RG 18	Hungary (EC168752)	Red	2	S, SP	NDC	S, O, DRC
RG 19	Hungary (EC168752)	Red	1	M, NSP	NDC	S, O, DRC
RG 20	Hungary (EC168752)	Red	1	M, NSP	DC	S, O, DRC
RG 22	Hungary (EC168754)	Red	0	M, NSP	NDC	S, O, DRC
RG 179	Hungary (EC168757)	Purple	0	M, SP	NDC	S, O, DRC
RG 181	Hungary (EC168759)	Red	1	M, SP	PDC	B, E, DRC
RG 17	Hungary (EC168752)	Red	2	S, SP	NDC	S, O, DRC
RG 180	Hungary (EC168758)	Purple	0	B, SP	PDC	S, O, DRC
RG 14	Unknown (EC103746)	Purple	0	S, SP	NDC	S, O, BR
RG 15	Unknown (EC151810)	Purple	0	S, SP	NDC	S, O, BR
RG 125	Unknown (EC103745)	Red	0	M, SP	NDC	S, O, DRC
DCS9 (EC[a])	India	Red	2	M, SP	NDC	M, O, BR
48-1 (MC)	India	Red	2	B, NSP	NDC	M, O, BR
Sowbhagya (LC)	India	Red	2	S, SP	NDC	S, O, BR
GCH 4 (MC)	India	Red	3	B, SP	NDC	M, O, BR

EC[a]: early maturing check; MC: medium maturing check; LC: late maturing check; EC: exotic collection identity number given by National Bureau of Plant Genetic Resources, New Delhi, India; 0: the absence of bloom; 1: the presence of bloom on stem; 2: the presence of bloom on stem and lower surface of leaf; 3: the presence of bloom on stem and lower and upper surface of leaf; B: big; M: medium; S: small; SP: spiny; NSP: non-spiny; NDC: non-dehiscent; PDC: partially dehiscent; DC: dehiscent; E: elongated; O: oval; DRC: dark chocolate; BR: brown.

commercial cultivars with different maturity durations. 'DCS 9' is an early maturing variety, 'Sowbhagya' is a late maturing cultivar and '48-1' and 'GCH 4' are medium maturing variety and hybrid, respectively. The 23 extra-early accessions, which were selected from 43 heterogeneous exotic collections, had under gone seven to eight generations of self-pollination to bring in genetic uniformity especially for the maturity related traits like number of main stem nodes, days to flowering and days to maturity and various morphological traits. Each test entry was planted in two rows, 5 m long, spaced 45 and 90 cm within and between rows, respectively in each replication. Recommended doses of fertilizers and plant protection measures were applied to experiment. Meteorological data were recorded using automatic weather station. The minimum and maximum temperatures varied from 20 to 22 °C and 31 to 34 °C, respectively and the total rainfall was between 609 and 1114 mm during crop period (June to March) during 2003–2004 to 2007–2008.

Data were recorded on 15 random plants in each entry in each replication for 14 quantitative traits *viz.*, plant height (cm), number of main stem nodes up to primary raceme, days to 50% flowering, days to maturity, total number of racemes/plant, total length of primary raceme (cm), primary raceme length covered by capsules (cm), 100-seed weight (g), oil content (%), seed yield at 120, 150, 180 and 210 days after planting (g/plant) and total seed yield (g/plant). Plant height (cm) was measured from ground surface to the base of primary raceme. Days to 50% flowering was measured as number of days taken from planting to flowering of primary racemes in 50% of plants of an entry. Number of days taken from planting to maturity of primary raceme was considered as days to maturity. Number of total productive racemes/plant was counted. Total length of primary raceme (cm) was measured from base to tip of the raceme. The part of primary raceme covered by capsules was measured as primary raceme length covered by capsules (cm). As castor is indeterminate in fruiting, harvesting was done in four pickings at 120, 150, 180 and 210 days after planting (DAP). Combined seed yield of all pickings was taken as total seed yield (g/plant). Seed oil content (%) was measured using NMR equipment. Per day productivity (g/plant) of each entry was calculated by dividing the seed yield (g/plant) of each entry at a particular picking (120, 150, 180 and 210 DAP) by its days to maturity. Cumulative per day productivity (g/plant) of each entry was calculated by dividing total seed yield by days to maturity. Data on 14 quantitative traits were analysed for each year as well as for five years combined using MSTATC software. Mean and range for 14 quantitative traits were computed. The variance components due to genotype (σ^2_g) and error (σ^2_e) were estimated in each year and also the variance component due to genotype × environment ($\sigma^2_{g\times e}$) for five years combined was estimated for 14 quantitative traits. Genotypic correlation coefficients among 14 quantitative traits were estimated for each year separately and also for five years combined. Entire data of all five years were combined to get pooled correlation coefficients. Genetic diversity among the test entries was assessed by cluster analysis using Ward's Minimum Variance. Visual observations of stem colour, bloom (waxy coating), capsule size, nature and dehiscence of capsule, and seed size, shape and colour were recorded for each entry. Capsule which had <1.5 cm diameter was classified as small and that with >3 cm diameter as big, while the one in between was taken as medium size capsule. Seed having <1.5 cm seed index (length × breadth) was considered as small seed while the one having >3 cm seed index was taken as big seed and the intermediate index one was considered as medium seed. Since measuring capsules and seed size is a time and labour consuming process, test entries were visually compared with commercial varieties namely 'Aruna', '48-1' and 'CO-1' for sizes of capsules and seeds. 'Aruna' was taken as a standard genotype for small size capsule (1.4 cm) and seed (1.2 cm) and '48-1' was for medium size capsule (2.5 cm)