Industrial Crops & Products 112 (2018) 766–774

Contents lists available at ScienceDirect

Industrial Crops & Products

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

Trait-specific accessions in global castor (*Ricinus communis* L.) germplasm core set for utilization in castor improvement

K. Anjani[a,*], M.A. Raoof[a], M. Santha Lakshmi Prasad[a], P. Duraimurugan[a], C. Lucose[b], Praduman Yadav[a], R.D. Prasad[a], J. Jawahar Lal[a], C. Sarada[a]

[a] ICAR-Indian Institute of Oilseeds Research, Hyderabad, 500030, India
[b] Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, Gujarat, India

ARTICLE INFO

Keywords:
Biotic stress
Castor
Core set
Germplasm
Resistance
Ricinoleic acid

ABSTRACT

Castor (*Ricinus communis* L.) is a non-edible industrial oilseed crop. Its oil has multiferous applications in industry. A vast castor germplasm collection of 3289 accessions is being maintained at ICAR-Indian Institute of Oilseeds Research, Hyderabad, India. The large size of castor germplasm has become a problem for evaluation, conservation and utilization. Hence, a core-set comprising 165 accessions representing diversity in the entire collection was developed. Though the core set is genetically diverse, its utilization in breeding programme is not picking up because of its still large size. In order to enhance efficacy of core set, an attempt was made in to identify core set accessions possessing resistance to major biotic stresses such as Fusarium wilt, root rot, gray mold and leafhopper, and desirable qualitative and quantitative traits. Screening against biotic stresses was done under artificial infestation conditions in field and greenhouse/ploy house at multilocations over years. Evaluation for stability of quantitative and qualitative traits was done at multilocations under rainfed and irrigated conditions. This study has thus identified 26 core set accessions possessing resistance to wilt, root rot, gray mold and leafhopper, and high ricinoleic acid content, high yield and seed weight and early maturity. These accessions would serve as instant basic resources for utilization in breeding programmes to improve castor for resistance to major biotic stresses as well for yield, ricinoleic acid content and early maturity. They also play an important role in diversifying the genetic base of working collection of castor breeders for developing improved cultivars with broad genetic base.

1. Introduction

Castor (*Ricinus communis* L.) is an important industrial oilseed crop grown in marginal lands. Its oil is used in production of wide range of industrial products such as biopolymers, aviation fuel, medicines etc. (Ogunniyi, 2006). The potential for castor oil to play a much larger role in the world economy had increased dramatically. India is the largest producer of castor and secured a virtual monopoly in castor production with 1751 thousand tones production from 1061 thousand ha area with 1652 kg/ha productivity in 2015–16. Mozambique, China and Brazil are the other major castor producing countries (http://www.fao.org/faostat/). India is considered as one of the centres of origin of castor because of existence of vast diversity in this species. The Indian Council of Agricultural Research-Indian Institute of Oilseeds Research (ICAR-IIOR), Hyderabad, India is the prime castor research centre in India. It currently holds around 3289 castor germplasm accessions, of which 3036 were collected through conduction of explorations in India (Anjani, 2012), and 253 accessions were introduced from 36 countries. However, conservation and maintenance of genetic purity of this vast global collection is expensive and labour intensive owing to prolonged indeterminate growth habit of castor plant. Castor is a cross-pollinating plant; wind is the main pollinating agent. Hence, production of large quantity of self-seed of each accession is a labour intensive and laborious task. The large size of germplasm collection is posing problems for multilocation evaluation. Enormous efforts are needed to evaluate the entire collection for traits of economic importance and to screen against biotic and abiotic stresses through reliable standardized techniques. This is a very expensive and time taking task. Therefore, there is lack of information on genotype x environment interaction of germplasm collections whose performance is often environment dependent. Consequently, the potentiality of germplasm is not being exploited fully by breeders; breeders tend to utilize the same in-house breeding pools in crop improvement programmes which results into utilization of the same genotypes repeatedly, and hence, narrow genetic base of breeding

* Corresponding author.
E-mail address: k.anjani@icar.gov.in (K. Anjani).

https://doi.org/10.1016/j.indcrop.2018.01.002
Received 16 September 2017; Received in revised form 1 December 2017; Accepted 3 January 2018

lines and released cultivars. In order to overcome these problems, a castor germplasm core set was developed from the entire collection of 3003 accessions available at that time at ICAR-IIOR (Sarada and Anjani, 2013). The core set is comprised of 165 accessions and represents the diversity present in the entire collection, and displayed excellent diversity for agro-morphological traits. Prior to establishing the core set each accession has undergone 7–8 generations of self-pollination and thus genetic uniformity was maintained in each accession. Senthilvel et al. (2016) showed low level of genetic relatedness and absence of population structure among the germplasm accessions comprising core set. This indicates presence of great genetic diversity in castor core set.

The difficulties involved in utilization of vast collection of germplasm in castor breeding programmes for enhancing genetic variation, and the low productivity of castor due to biotic stresses has necessitated the germplasm curators to identify sources of resistance to biotic stresses as well accessions possessing desirable economic and quality traits in the castor core set as it represents the diversity present in the entire collection. Hence, the main objective of this study was to identify trait-specific accessions in castor core set so as to further enhance efficiency of core set in breeding programmes to develop new high yielding cultivars with a broad genetic base. Castor productivity is adversely affected by several biotic stresses. Fusarium wilt [*Fusarium oxysporum* f.sp. *ricini* (Nanda and Prasad)], Macrophomina root rot [*Macrophomina phaseolina* (Tassi) Goid], gray mold [*Botryotinia ricini* (Godfrey) Whetzel] and leafhopper [*Empoasca flavescens* (F.)] are some of the major biotic stresses in castor and can cause more than 80% yield loss (Anjani et al., 2004). Since host plant resistance is the major component in the management of diseases and insect pests in castor, the accessions comprising core set were screened along with other accessions against major biotic stresses such as Fusarium wilt, Macrophomina root rot, gray mold and leafhopper at different locations under artificial infestation conditions in different years. In addition, the promising accessions identified based on first year evaluation for economic and phenological traits at two locations were later evaluated at four locations under rainfed and irrigated conditions. The screening and evaluation results are discussed in the present paper in order to increase the efficacy of core collection in castor improvement programmes.

2. Material and methods

2.1. Screening against wilt

2.1.1. Wilt sick plot

The 165 accessions comprising the core set were screened against wilt (*F. oxysporum* f. sp. *ricini*) disease during rainy season in permanent wilt sick plots maintained at ICAR-IIOR, Hyderabad (17.366°N and 78.478°E), and S.K. Nagar (24.19°N and 72.19°E), an All India Coordinated Research Project (AICRP) on Castor centre. The core set accessions were screened separately over years (2001–2012) in sick plots. The susceptible check, JI-35/VP-1/Aruna/GAUCH-1 and the resistant check, 48-1/DCS-9 were sown after every five or 10 rows of test entries to determine the uniform spread of inoculum across the sick plot. All the checks used are commercial castor cultivars. Each test entry was sown in a single row of 5 m length with spacing of 60 × 30 cm. The permanent wilt sick plots at Hyderabad and S.K. Nagar were developed by growing highly susceptible variety, Aruna/VP1/JI-35/GAUCH-1/Kranthi and also *in situ* incorporation of infected plant debris of susceptible varieties, and also inoculum was incorporated in wilt sick plots prior to sowing. Wilt pathogen, *F. oxysporum* f. sp. *ricini* was isolated from naturally infected wilted root and multiplied on sterilized sorghum grain medium for 14 days in bulk amount. The wilt infected sorghum grains were applied in furrows after 20 days of sowing. The inoculum load of *F. oxysporum* f. sp. *ricini* in soil was tested before and after sowing and also at the end of the trial by following standard soil dilution method. Inoculum load of 2–3 × 10^3 CFU/g of soil was being maintained in the sick plot. The observations on germination and wilt incidence at 30 days interval up to 150 days after sowing were recorded. The data on total plant count and infected plants were recorded. Wilt incidence was derived from the formula: [(number of wilted plants/total number of plants) x 100]. Number of wilted plants were recorded at different intervals. At each interval, the newly wilted plants were counted leaving the previously infected ones; finally the wilted plants counted at each interval were cumulated to calculate wilt incidence of each genotype. Reaction of experimental material against wilt was categorized as per the scale given by Lakshminarayana and Raoof (2006). Based on the wilt incidence, the genotypes found free from wilt disease (0% wilt disease) were regarded as highly resistant. The cultivars with wilt incidence up to 20% were classified as resistant and those with more than 20% wilt incidence were considered as susceptible. Germplasm accessions showing resistant reaction in wilt sick plot at three locations were reconfirmed by root-dip inoculation method (Raoof and Nageshwar Rao, 1996) in greenhouse at ICAR-IIOR, Hyderabad and S.K. Nagar.

2.1.2. Root-dip inoculation method

The surface sterilized seeds of each germplasm accession were sown in autoclaved sand filled with plastic trays. The trays are watered as and when needed. *F. oxysporum* f. sp. *ricini* was isolated from naturally wilt infected castor roots on potato dextrose agar medium. The pure culture of fungus was grown on sterilized sorghum grains for 10-14 days. The spore suspension was prepared by transferring a few infected sorghum grains into distilled water to maintain concentration of 1 × 10^6 spores/ml. Ten days old seedlings of individual accession were carefully uprooted, washed thoroughly with tap water and, then the clipped root tips were dipped for 1–2 min in the spore suspension. Inoculated seedlings were transplanted in the earthen pots filled with autoclaved soil; twenty seedlings were maintained for each accession. The resistant and susceptible checks were screened along with the test material. Suitable controls were maintained by dipping the trimmed seedlings in sterile distilled water and transplanted into the pots. The plants were observed for wilt symptoms and observations on wilt incidence were recorded periodically up to 30 days after transplanting.

2.2. Screening against root rot

2.2.1. Root rot sick plot

The 165 accessions of core set were screened along with other germplasm accessions against root rot in a permanent root rot sick plot at Main Oilseeds Research Station, Junagadh Agricultural University, Junagadh, India (21.31°N and 70.33°E). The accessions of core set were screened separately over years from 2003-04 to 2015–16. Screening of germplasm accessions against root rot was done initially in the permanent root rot sick plot along with susceptible check, GCH-4 and resistant check, JI-357 planted after every five test rows at 90 × 45 cm spacing. GCH-4 is a commercial castor hybrid and JI-357 is an inbred line. The root rot pathogen, *M. phaseolina*, was isolated from naturally infected castor plants and grown on sorghum sand medium for 14 days. The sorghum culture mixed with sand was applied in furrows at the time of sowing. The experimental materials were categorized as per Mayee and Datar (1986). The germination percentage and root rot incidence at 120, 150 and 180 days after sowing were recorded. The ratio of number of root rot infected plants to total number of plants multiplied by 100 was considered as root rot incidence percentage. Number of plants infected by root rot at different intervals were recorded. At each interval, the newly infected plants were counted leaving the previously infected ones; finally the root rot infected plants counted at each interval were cumulated to calculate root rot incidence of each genotype.

2.2.2. Stem tape inoculation method

The germplasm accessions which showed resistant reaction in root rot sick plot were evaluated against root rot by stem tape inoculation