1. Introduction

Castor (*Ricinus communis* L.) belonging to *Euphorbiaceae* family is an important non-edible industrial oilseed crop. The potential for castor oil to play a much larger role in the world economy had increased dramatically because of its multifarious applications in production of wide industrial products ranging from medicines to aviation fuels, fuel additives, biopolymers and biodiesel (Ogunniyi, 2006). Global demand for castor oil is rising constantly at 3–5% per annum (http://www.castoroil.in). India is the largest producer of castor (*Ricinus communis* L.) in the world and secured a virtual monopoly in castor production with 17.51 lakh tones production from 10.61 lakh ha area with 1652 kg/ha productivity. Mozambique, China and Brazil are the other major castor producing countries (http://www.fao.org/faostat/).

R. communis is monophyletic (Webster, 1994). The earlier identified 91 species, subspecies and varieties in Ricinus genus (Popova, 1930; Hilderbrandt, 1935) are now believed to be synonymous to *R. communis* as it is untenable to consider them as separate species because of easy intercrossability and production of fertile intermediates, and lack of discretion of species based on morphological characteristics, geographical demarcation and chromosome number. The variability exists among earlier described species does not exceed the overall characteristics of *R. communis*.

There are varied opinions about the site of origin of castor. The Ethiopian-East African region is considered to be the most probable site of origin (Moshkin, 1986). India is also one of the centres of origin as tremendous natural diversity in castor is widespread in the country. Semi-wild and wild perennial castor forms are found growing in diverse habitats like forests, sea coast, river beds, open-cast coal mines, hill tops, mountain-valleys, roadsides, field bunds, railway tracks, garbage dumps, wastelands, backyards and many other areas across the country (Fig. 1).

Fig. 1. Castor growing at sea shore in Andaman & Nicobar Islands, India

2. Castor germplasm collection and unique morphotypes

The Castor Germplasm Management Unit at ICAR-IIOR, Hyderabad is currently maintaining 3289 accessions, of which 253 were introduced from 36 countries through ICAR-NBPGR, New Delhi, and the remaining 3036 indigenous accessions were collected through conduction of explorations in Andaman and Nicobar Islands and 22 States namely, Andhra Pradesh, Assam, Bihar, Gujarat, Haryana, Himachal Pradesh, Jammu and Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Nagaland, Orissa, Punjab, Rajasthan, Tamil Nadu, Telangana, and Uttar Pradesh (Anjani et al. 1993, Anjani et al. 1994, Duhoon et al. 1996, Anjani et al. 1999, Ashoka Vardhana Reddy et al. 2002, Sunil et al. 2007, Anjani, 2001).

The entire collection of 3289 accessions has been characterized using 23 morphological descriptors developed at ICAR-IIOR, and the same accessions have been characterized for 19 quantitative traits. This has led to identification of several unique and rare phenotypes (Fig. 2, 3) and sources of resistance to major biotic and abiotic stresses to utilize in breeding programmes of All India Coordinated Research Project (ACIRP) on Castor.

Fig. 2. Unique castor morphotypes: a) purple colour castor, b) papaya leaf type castor c) large leaf type, d) diversity in castor seed traits

Fig. 3. Different capsule colored castor morphotypes

3. Diversity in castor genetic resources for quantitative traits

Total collections were evaluated for various agronomic, economic and quality traits. Great diversity for these traits was observed among collections (Table 1). Several accessions were identified among Indian collections for desirable traits like dwarf plant type (<100 cm), very low number of nodes on main stem (5-7), extra early flowering (30-32 days), early maturity (<110 days), long primary raceme covered with capsules (76-77cm), very heavy seed (75-87 g/100 seed), high oil content (50-54%), high ricinoleic acid contents (90-92%) and high seed yield at multiple harvests (Fig. 4). Extra-early accessions that mature in less than 90 days were selected from heterogeneous populations of exotic collections introduced from the former USSR, USA and Hungary (Anjani, 2010a). These are of great value to breed extra-early castor cultivars as well to identify genes responsible for extra-earliness.

Fig.4. Indigenous collection possessing a) very long spike, b) dwarf plant type, c) bold seed, and d) tall plant type

Table.1. Diversity in castor genetic resources for various agronomic, phenological and economic traits

Trait	Min.	Max.	Mean	SEm	Trait	Min.	Max.	Mean	SEm
Plant height (cm)	11	399	100	0.9	Days to 50% flowering	30	148	61	0.27
No. of main stem nodes	5	39	16	0.08	Days to maturity	76	263	115	0.27
Total length of primary spike (cm)	8	85	34	0.18	100-seed weight (g)	7	87	27	0.13
Effective length of primary spike (cm)	0	73	10	0.13	Oil content (%)	28	54	48	0.05
Length of primary spike covered with capsules (cm)	2	77	24	0.19	Seed yield at 120 Days after planting (g/plant)	0	250	25	0.39

No. of secondary spikes/plant	0	10	3	0.02	Seed yield at 150 Days after planting (g/plant)	0	140	21	0.34
No. of tertiary spikes/plant	0	8	3	0.02	Seed yield at 180 Days after planting (g/plant)	0	266	25	0.47
No. of higher order spikes/plant	0	10	3	0.02	Seed yield at 210 Days after planting (g/plant)	0	297	24	0.44
Total no. of spikes/plant	1	19	11	0.05	Total seed yield (g/plant)	2	450	93	1.07

3a. Molecular diversity: Considerable diversity at molecular level was observed among the collections from north-eastern States and Andaman & Nicobar Islands (Fig. 5), which form ecologically diverse regions (Meena et al 2014; Meena et al 2015).

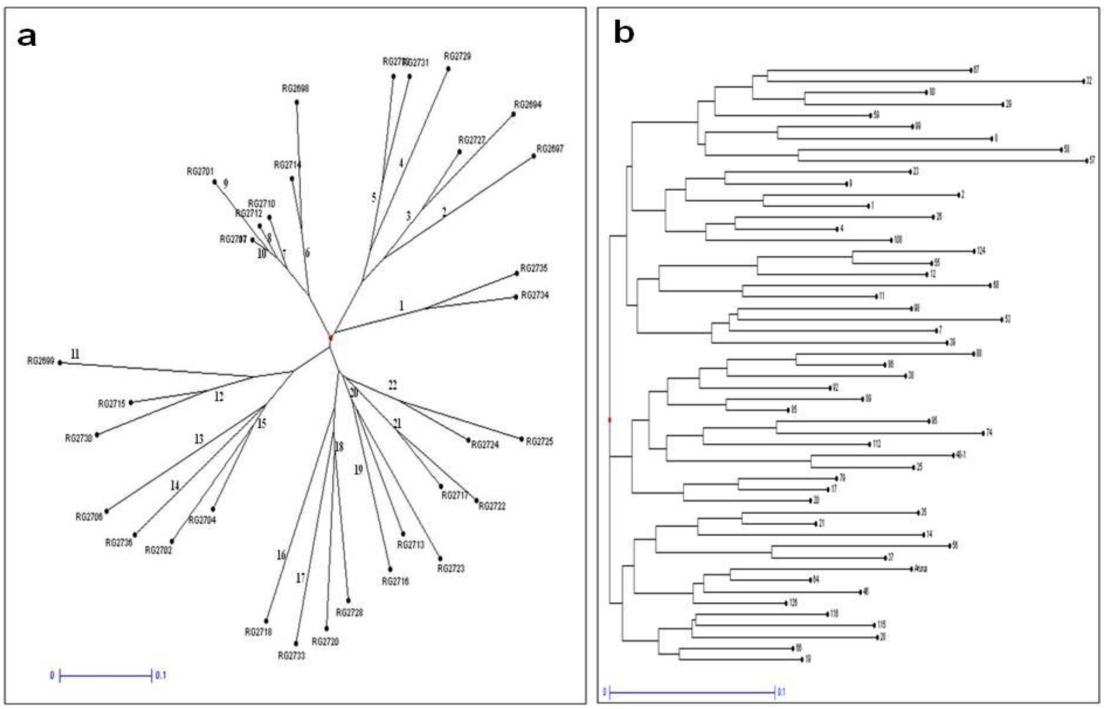

Fig.5. Molecular diversity among collections from (a) Andaman & Nicobar Islands, and (b) North-eastern States

4. Accessions identified for phenological traits and high seed yield and yield traits

Based on multilocation and multiyear evaluation of castor germplasm accessions under both rainfed and irrigated conditions, several accessions possessing high yielding capacity, promising yield traits, high oil and ricinoleic acid contents and phenological traits were identified (Table 2).

Table 2. Accessions identified for phenological traits and high seed yield and yield traits based on multi-location evaluation

Specific-trait	Accessions	No. of accessions	Description of specific-trait in identified accessions	Description of specific-trait in check (GC-3)
Extra early maturity & high ricinoleic acid	RG-22	1	Ricinoelic acid: 90% Days to maturity: Under irrigation: 107 days Under rainfed: 82 days	Ricinoleic acid: 88% Days to maturity: under irrigation: 115 days under rainfed: 110 days
Early maturity	RG-3548	1	Days to maturity: Under irrigation: 130 days Under rainfed: 110 days	Days to maturity: under irrigation: 115 days under rainfed: 110 days
Early maturity, wilt &leafhopper resistant	RG-43	1	Days to maturity: Under irrigation: 126 days Under rainfed: 100 days	Days to maturity: under irrigation: 115 days under rainfed: 110 days
Long length of primary spike covered with capsules	RG-3798	1	length of PS: Under irrigation: 64 cm Under rainfed: 52 cm	Length of PS: under irrigation: 41 cm under rainfed: 38 cm
Heavy seed (100-seed weight)	RG-2104 RG-2184 RG- 2433	3	Overall mean 100-seed weight: 75-87 g	Overall mean 100-seed weight: 27 g
High seed yield	RG-2685 RG-3445 RG-707	3	Overall mean seed yield: 2267-2424 g/plot*	Overall mean seed yield: 2067 g/plot
High yield, high oil & wilt resistant	RG-3100	1	Oil content: 50% Overall mean seed yield: 2104g/plot*	Oil content: 48% Overall mean seed yield: 2067 g/plot
High yield & high ricinoleic acid	RG-3477 RG-3799 RG-3160 RG-3206 RG-3491 RG-3798	6	Ricinoleic acid: 90-91% Overall mean seed yield: 2044 - 2364 g/plot	Ricinoleic acid: 88% Overall mean seed yield: 1898 g/plot
High yield, & wilt resistance	RG-155	1	Overall mean seed yield: 2044 g/plot*	Overall mean seed yield: 1898 g/plant

*Plot size: under irrigation: 14.4 m^2 , under rainfed: 10.8m^2

5. Accessions identified for quality traits

Castor oil is the only source of ricinoleic acid, which comprises approximately 85% of the fatty acid composition of the oil. This makes castor oil a unique source for preparation of thousands of derivatives suitable to prepare a number of products in several industrial fields: medicines, cosmetics, paints, coatings, soaps, inks, telecommunications, biopolymers, lubricants, special aviation fuels, biofuel and several others. None of the released castor cultivars are having above 88% ricinoleic acid. Any increase in ricinoleic acid content beyond 88% would be beneficial to industry. This would increase the value of castor oil. In the ICAR-IIOR castor repository 25 accessions have been identified for high ricinoleic acid content (90-92%) (Praduman and Anjani, 2017) based on multi-location and multi-year evaluation (Table 3). These would serve as sources for high ricinoleic acid to develop high ricinoleic type cultivars.

Table 3. Accessions identified for high ricinoleic acid and high oil contents based on multi-location, multi-year evaluation

Specific-trait	Accessions	No. of accessions	Description of specific-trait in identified accessions	Description of specific-trait in check (GC-3)
High ricinoleic acid content (%)	RG-22, RG-57, RG-63, RG-66, RG-226, RG-329, RG-330, RG-357, RG-358, RG-380, RG-408, RG-1741, RG-2451, RG-2685, RG-3233, RG-3445, RG-3454, RG-3467, RG-3477, RG-3722, RG-3741, RG-3772, RG-3795, RG-3799	24	90-92	88
High ricinoleic acid content (%) & wilt resistance	RG-311	1	90.2	88
High oil content (%)	RG-2364, RG-3100, RG-707	3	50-51	48

Great diversity exists in castor germplasm for seed oil content (Fig. 6). The average oil content in castor germplasm collection was 48%; three accessions with 50-51% high oil content were indentified based on multi-location and multi-year evaluation (Table 3).

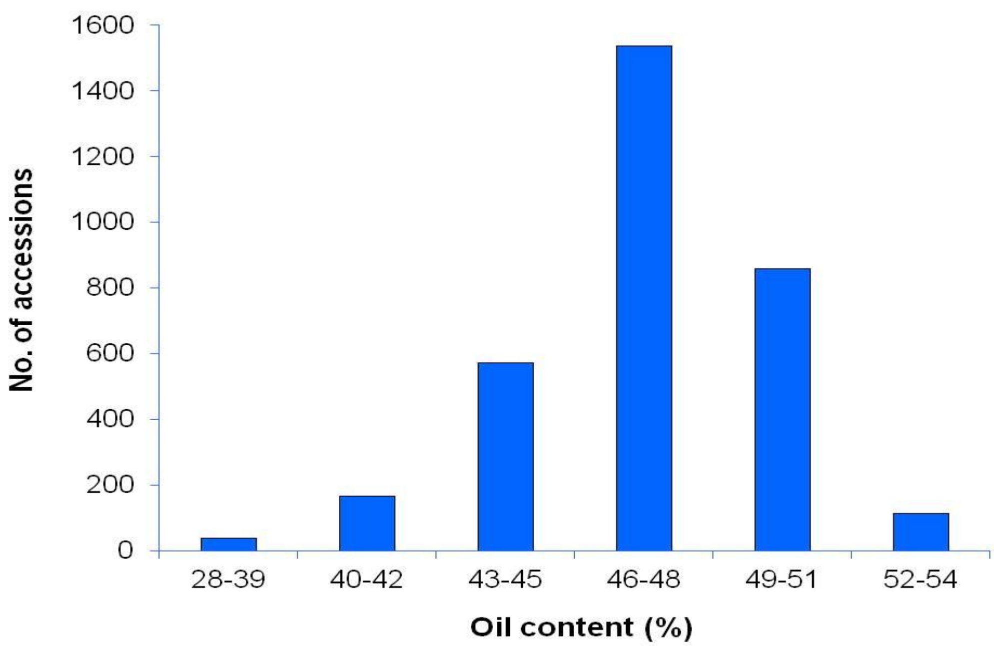

Fig.6. Frequency distribution of oil content in castor germplasm

6. Accessions identified for long longevity under uncontrolled storage conditions

It was demonstrated at ICAR-IIOR, Hyderabad that some castor accessions have ability for long longevity (11-19 years), while some lost longevity after 5 years storage and all germplasm accessions could maintain viability for 4 years under uncontrolled storage conditions (Anjani and Jawaharlal, 2015). Total 26 accessions were indentified for long longevity under uncontrolled storage conditions. One accession, RG-2089 showed 40% germination when planted in the field after storing for 19 years and 25 accessions germinated 80-100% after storing for 11-14 years under uncontrolled storage conditions (Table 4).

Table 4. Accessions identified for long longevity under uncontrolled storage conditions

Accession	Storage duration (years)	Germination percentage	Accession	Storage duration (years)	Germination percentage
RG-2089	19	40	RG-1668-1	13	80
RG-29	14	80	RG-1695	13	90
RG-602	14	80	RG-1969	13	100
RG-691	14	80	RG-2065	13	80
RG-854	14	90	RG-2210	13	100
RG-860	14	80	RG-2067	12	80
RG-911	14	80	RG-97	11	80
RG-1298	14	100	RG-659	11	80
RG-1389-1	14	80	RG-817	11	100
RG-1456	14	80	RG-931	11	100
RG-1525	14	80	RG-1594	11	100
RG-2068	14	100	RG-2296	11	100
RG-1663	13	80	RG-2350	11	100
			$LSD_{0.05}$		5.98

7. Sources of resistance to biotic stresses

Fusarium wilt caused by *Fusarium oxysporum* f.sp. *ricini*, Botrytis gray mold incited by [*Botryotinia ricini* (Godfrey) Whetzel] and Macrphomina root rot caused by [*Macrophomina phaseolina* (Tassi) Gold] are the major yield losing diseases in castor in the country. Under sever disease conditions they can cause complete loss of yield. In castor germplasm the accessions were screened under artificial epiphytotic conditions against wilt (root-dip inoculation technique and wilt sick pot), Macrophomina (stem-tape inoculation technique) and Botrytis gray mold (Poly-house).

Screening against wilt resistance was done initially in wilt sick plots at IIOR, Hyderabad, S. K. Nagar and Palem. The accessions which were found resistant to Fusarium wilt (0-20%) at all the three locations were again confirmed for resistance using root-dip inoculation method or by growing in wilt sick pots in glasshouse at IIOR, Hyderabad, S. K. Nagar and Palem. The accessions which showed resistance reaction at all the three locations in wilt sick pots/ root-dip inoculation method were identified as resistant sources (Fig. 7). The resistant check used in wilt screening experiments was 48-1 while the susceptible check was JI-35.

Screening of germplasma against Macrophomina root rot was taken up initially in root rot sick plot at Junagadh (Fig. 8) and thus identified resistant sources were again confirmed using stem-tape inoculation technique in glasshouse. The susceptible check used in root rot screening experiments was GCH-4 and the resistant check was JI-357.

Germplasm accessions were screened against Botrytis gray mold initially in the field under naturally occurred high disease severity at ICAR-IIOR, Hyderabad and Chintapalle; the accessions which were found resistant at both locations were confirmed for resistance in poly-house under artificial inoculation conditions and spike-detached technique in growth chamber. DCH-519 was the susceptible check in Botrytis screening experiments. Based on screening under artificial epiphytotic conditions, several resistance sources against Fusarim wilt, Macrophomina root rot and Botrytis gray mold were identified among castor genetic resources (Table 5). The Botrytis grey mold resistant sources still need further confirmation.

Several insects attack castor, among them leafhopper (*Empoasca flavescens*), *Spodopter litura* and semilooper are the major insect pests of castor in India. Castor germplasm was screened against leafhopper at IIOR, Hyderabad, Palem, and Yethapur. The accessions which showed resistance reaction at all the locations under late sown conditions have been further screened using infester-row method for confirming the resistance reaction (Fig. 9). DCS-9 and DCH-177 were used as susceptible checks and DCH-519 as the resistant check in the screening blocks.

Screening against leafminer was done from August to November under severe pest infestation conditions and resistant accessions were confirmed over years in the field and by assessing total phenol content in resistant accessions and susceptible checks (Fig.10). There was a high positive correlation between total phenol content and resistance to laefminer (Anjani et al. 2010b; Prasad and Anjani, 2001). Several accessions were identified as sources of resistance to leafhopper and leafminer in castor germplasm (Table 5).

The accessions showing resistance to different diseases and insect pests were screened again for multiple resistance and the accessions showing multiple resistance were confirmed using artificial inoculation/infestation techniques. Thus castor germplasm accessions showing resistance to wilt and root rot, wilt and leafhooper, and wilt, root and Botrytis were identified (Table 5).

Table 5. Sources of resistance to different biotic stresses identified among castor germplasm under artificial inoculation/ screening conditions

Biotic stress	Resistant germplasm accessions	No. of accessions
Diseases		
Fusarium wilt	RG-109, RG-155, RG-224, RG-297, RG-386, RG-311, RG-558, RG-1608, RG-1624, RG-2430, RG-2758, RG-2781, RG-2818, RG-3016, RG-3042, RG-3070	16
Macrophomina root rot	RG-104, RG-529, RG-2816, RG-2035	4
Botrytis *	RG-1963,RG-3088	2
Insect pests		
Leafminer	RG-1930, RG-2008, RG-1766, RG-1771	4
Leafhopper	RG-2661,RG-631, RG-3060,RG-2462, RG-2093,RG-1621, RG-RG-3037, RG-3067	8
Multiple biotic stresses		
Wilt, root rot, Botrytis[$]	RG-2787	1

Wilt & root rot	RG-47, RG-111, RG-392, RG-2430, RG-2821, RG-2822, RG-2819	7
Wilt & leafhopper	RG-43	1

*needs further confirmation; $^{\$}$moderate resistance to Botrytis

Fig. 7. Reaction of Fusarium wilt resistant accessions and susceptible check, JI-35 in wilt-sick plot and wilt-sick pot under artificial epiphytotic conditions. JI-35 succumbed to wilt

Fig. 8. Reaction of resistant accession (R) and susceptible check (S) in root-rot sick plot. Susceptible check succumbed to root rot

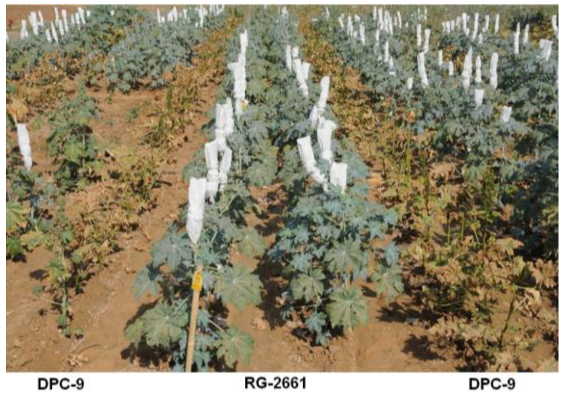

Fig. 9. Reaction of resistant accession, RG-2661 and susceptible check, DPC-9 against leafhopper in infester-row method. DPC-9 succumbed to leafhopper infestation

Fig.10. Reaction of resistant accession, RG-1930 and susceptible check, DCS-107 against leafminer. Leaf of DCS-107 was fully mined by leafminer while that of RG-1930 was free from mines

7a. Inheritance of disease and insect resistance: The role of digenic epistatic interactions on wilt resistance was identified. The duplicate dominant (15:1), duplicate recessive and dominant (9:7) and recessive epistatic interactions (13:3) were noted in inheritance of wilt resistance (Anjani et al. 2014). This study suggested that parental selection should be based on their inheritance mode for utilizing in wilt resistant hybrid breeding programme.

Uniparental inheritance was observed for leafminer resistance when leafminer resistant purple leaf morphotype, RG-1930 was used as a female parent. The resistance was not inherited when RG-1930 was used as male parent (Anjani et al. 2007). High positive relation between total phenol concentration and resistance against leafminer was also established (Anjani et al. 2010b).

8. Sources of resistance to abiotic stresses

Castor though considered as a moisture stress tolerant species but its growth and yield reduce severely under drought conditions. Castor germplasm accessions were screened in lab for drought tolerance (using polyethylene glycol method) and salinity tolerance (with NaCl) during germination, and seedling survival for temperature tolerance (using TIR method). The accessions with good root trait and drought tolerance indentified in lab were confirmed for drought tolerance in the field by imposing drought stress at 30-90 days after planting in *rabi* season (Radhamani et al 2014). Thus several germplasm accessions have been identified for tolerance to drought, temperature and salinity (Table 6).

9. Accessions identified for both biotic and abiotic stress tolerance: A unique accession, RG-111 was identified under artificial inoculation or epiphytotic conditions as a stable source of resistance to Fusarium wilt, Macrophomina root rot and drought in lab and field under imposed drought condition (Table 6).

Table 6. Accessions identified for abiotic stresses tolerance

Abiotic stresses	Tolerant accessions	No. of tolerant accessions
Drought	RG-72, RG-82, RG-89, RG-111, RG-248, RG-272, RG-289, RG-298, RG-415, RG-1494, RG-2048, RG- 2139,RG-2474, RG-3013, RG-3063, RG-3116	16
Temperature	RG-72, RG-89, RG-111, RG-211, RG-282, RG-941, RG-1618, RG-1661, RG-1826, RG-1941, RG-2048, RG-2059, RG-2094, RG-2153, RG-2439, RG-3063	16
Salinity	RG-72, RG-289, RG-298, RG-539, RG-941,RG-1463, RG-1582, RG-2149	8
Drought & salinity	RG-72, RG-289, RG-298	3
Drought & temperature	RG-72, RG-89, RG-111, RG-2048, RG-3063	5
Drought, temperature & salinity	RG-72	1
Drought, temperature, wilt & root rot	RG-111	1
Temperature and salinity	RG-941	1

NOTE: All the abiotic resistant accessions need further confirmation under real natural conditions

10. Castor germplasm registration

Total 15 accessions possessing various promising traits have been registered with Plant Germplasm Registration Committee (PGRC), ICAR-NBPGR (Table 7).

Table 7. Castor germplasm accessions registered with PGRC, ICAR-NBPGR

Accession	IC No.	INGR No.	Specific trait
RG-1930	IC 296922	INGR03032	Resistance to leafminer, purple colour, high total phenol
RG-392	IC 373897	INGR 98033	Resistance to wilt & moderate resistance to root rot
RG-47	IC 373867	INGR 98034	Resistance to Fusarium wilt & Macrophomina root rot
RG-297	IC296578	INGR 03069	Resistance to Fusarium wilt
RG-1608	IC 373978	INGR 04104	Resistance to Fusarium wilt
RG-2722	IC306138	INGR 04103	Resistance to Macrophomina root rot
RG-2819	IC346591	INGR06010	Resistance to Macrophomina root rot & Fusarium wilt
RG-1771	IC522120	INGR08030	Resistance to serpentine leafminer & papaya leaf type
RG-2787	IC374319	INGR09035	Resistance to wilt, root rot, & moderate resistance Botrytis grey rot
RG-43	IC0584671	INGR10135	Resistance to leafhopper, moderate resistance to wilt, early maturity

RG-2818	IC346622	INGR14004	Resistant to Fusarium wilt
RG-2822	IC0346626	INGR14028	Resistant to Macrophomina root rot
RG-72	IC274758	INGR08085	Early maturity & moisture stress tolerance
RG-19	IC0612166	INGR15008	Non-spiny, Extra-early maturity
RG-18	IC0585930	INGR10136	Early maturity (84 days), high per day productivity, high yield

11. Extra-early genenpool

An extra-early genepool was developed through random mating among 17 extra-early accessions for six years under isolation for enhancing broad genetic base for developing high yielding extra-early varieties (Anjani and Reddy, 2003). The genetic base of the genepool has improved over extra-early parental accessions with regard to seed yield and yield traits at the same time the genepool was akin to parental accessions with regard to days to 50% flowering, days to maturity and number of nodes on main stem (Fig. 11). The genepool has been distributed to all castor breeders in AICRP on Castor.

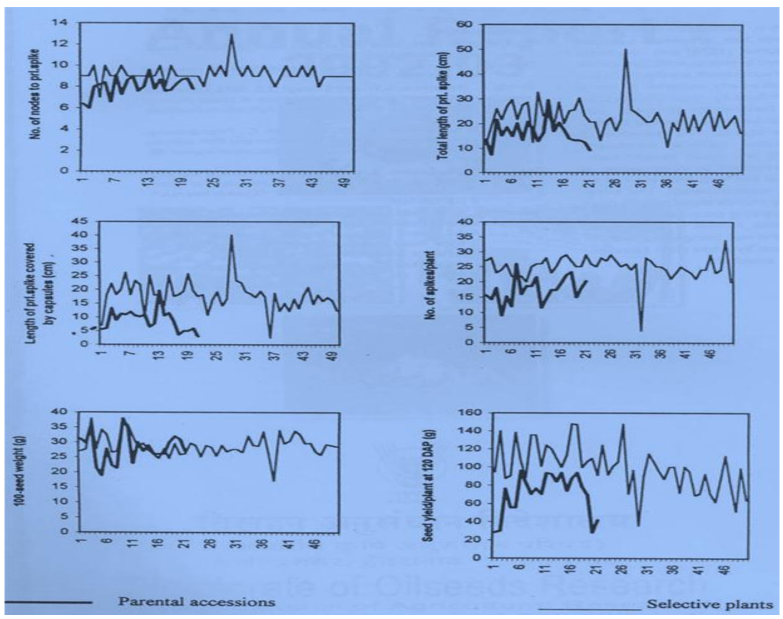

Fig. 11. Diversity in extra-early parents and selected progenies from extra-early genepool for seed yield and its traits

12. Castor core collection

Established an effective castor germplasm core collection comprising 165 accessions representing the maximum diversity existing in the entire collection of germplasm (Sarada and Anjani, 2013).

13. Utilization of germplasm

Several promising germplasm accessions possessing resistance to wilt, root rot, leafhopper and leafminer, tolerance to *Botrytis*, high yield and yield traits, oil content, short duration, pistillate type have been utilized in castor breeding programmes of AICRP on Castor for developing diverse productive male and female lines with resistance to wilt and leafhopper, wilt resistant pistillate lines and high yielding varieties, short and medium duration high yielding varieties, disease and insect resistant inbred lines (Table 8). Details of centre-wise germplasm utilization, crosses made using germplasm and purpose of utilization in breeding programmes are given in Annexure-I.

Table 8. Utilization of castor germplasm in castor improvement at different AICRP-Castor centres

Centre	No. of accessions utilized in breeding	No. of crosses made using germplasm	Registered accessions used in breeding
ICAR-IIOR	153	429	RG-47, RG-297, RG1771, RG-2787, RG-72
S.K. Nagar	28	81	RG-392, RG-109, RG-2787, RG-2819
Palem	34	42	RG-18, RG-109,RG-297, RG-2787
Junagadh	26	104	RG-2787, RG-2819, RG-297, RG-43
Mandor	7	31	RG-1771
Bawal, Anand Hirur,Navasari, Yethapur, Kanpur, Bhavanipatna,	40	166	RG-19, RG-297, RG-2787, RG-2822, RG-43, RG-47
Total	288	853	13

14. Success stories of genetic introgression of desirable traits from germplasm

Several high yielding wilt resistant male parental lines, wilt resistant pistillate lines, high yielding inbred lines have been developed by introgressing desirable traits from germplasm accessions. The inbred lines and pistillate lines developed using germplasm and reported by breeders in Castor Annual Reports of various years are given in the Table 9.

Table 9. Inbred and pistillate lines developed using germplasm for specific traits

Inbreds/pistillate lines	No. of lines	Specific trait
Inbred lines SKI 8, SKI56, SKI 71,SKI 73, SKI 87, SKI88, SKI 97, SKI 98, SKI 123, SKI 124, SKI 133, SKI 154, SKI 170, SKI 189, SKI 192, SKI 201, SKI 210, SKI 221, SKI 226, SKI 227, SKI 234, SKI 238, SKI 242, SKI 244, SKI 245, SKI 246, SKI 262, SKI 269, SKI 273, SK I276, SKI 281, SKI 282, SKI 294, SKI-303 , SKI-314, , SKI-325 , SKI-344, DCS-28, DCS-75, DCS-76, DCS-77	41	High yielding wilt resistant inbred lines
Pistillate lines DPC 12, DPC 15, PPL-23/2, SKP 4, SKP5, SKP6, SKP13, SKP16, SKP19, SKP23, SKP112, SKP 117	12	Pistillate

14.a Varieties developed involving germplasnm: Eight castor varieties have been developed involving germplasm accessions during their developmental process (Table 10)

Table 10. Castor varieties developed utilizing germplasm in their development

Variety	Germplasm used
Bhagya	RG-375/HO
Sowbhagya	RG-634/Short mutant
RC-8	RG-1188/RC1188
SA1	RG-273/RC1094
TMV-5	RG-1685/SA-2
TMV 6	RG-268/ RC962
Jyoti (DCS-9)	RG-400/240
Kranti (PCS-1)	RG-403/413-A

15. References

Anjani, K., 2001. Exploration of castor (*Ricinus communis* L.) germplasm in Andaman and Nicobar Islands. IBPGR Newsletr. for Asia the Pacific and Oceania 34,10.

Anjani, K., 2010a. Extra-early maturing germplasm for utilization in castor improvement. Ind. Crops and Prod. 31, 139-144.

Anjani, K., Chakravarty, S. K., Prasad, M. V. R., 1994. Collecting castor (*Ricinus communis* L.) germplasm in North-Eastern Hill Province of India. IBPGR Newsletr. for Asia The Pacific and Oceania 17,13.

Anjani, K., Duhoon, S. S., Yadav, W. S., 1999. Collecting castor (*Ricinus communis L.*) germplasm in northwestern India. Pl. Genet. Resour. Newsletr. 120, 48-51.

Anjani, K., Jawaharlal,J. 2015. Differential longevity of castor (*Ricinus communis* L.) germplasm conserved under uncontrolled storage conditions across extended periods. J Crop Improvement,29:706-716. DOI 10.1080/15427528.2015-1079758

Anjani, K., Pallavi, M., Sudhakara Babu, S. N., 2007. Uniparental inheritance of purple leaf and the associated resistance to leafminer, *Liriomyza trifolii* (Burgess) (Diptera: Agromyzidae) in castor bean (*Ricinus communis* L.). Plant Breedingd. 126, 515-520.

Anjani, K., Palliva, M., Sudhakara Babu, S. N., 2010b. Biochemical basis of resistance to leafminer in castor (*Ricinus communis* L.). Ind. Crops and Prod. 31, 192-196.

Anjani, K., Ramachandram, M., Tomar, J. B., 1993. Collecting castor (*Ricinus communis* L.) germplasm in Bihar, India. IBPGR Newsletr. for Asia The Pacific and Oceania 11,15.

Anjani, K., Raoof, M.A., Desai, A.G. 2014. Evaluation of world castor (*Ricinus communis* L.) germplasm for resistance to Fusarium wilt (*Fusarium oxysporum* f. sp. *ricini*). European J Plant Pathology. 139:567–578

Anjani, K., Reddy, A.K. P., 2003. Extra -early maturing genepool in castor (*Ricinus communis*). J of Oilseeds Research, 20, 213-216. Print ISSN**:** 0970-2776

Duhoon, S. S., Anjani, K., Kopper, M. N., 1996. Collecting castor (*Ricinus communis* L.) and *Jatropha* germplasm in Indo-Gangetic plains. Ind. J. Pl. Genet. Resour. 9, 171-174.

Hilderbrandt, V. M., 1935. The plant resources of the world as initial material in plant breeding. In: The Castor Plant, No. 6. Lenin Academy of Agricultural Sciences, Institute of Plant Industry, Moscow and Leningrad, pp.55-70.

Meena Kanti., Anjani K., Usha kiran B., Vivekananda, K.2015. Agro-morphological and Molecular Diversity in Castor (*Ricinus communis* L.) Germplasm Collected from Andaman and Nicobar Islands, India. Czech J. Genetics Plant Breeding, 51, 2015 (3): 96–109

Meena Kanti., Anjani, K., Venkat Ramya, K. 2014. Molecular Diversity in Castor Germplasm Collection Originated from North-Eastern Hill Province of India. International Journal of Research and Scientific Innovation. Volume I, Issue VI, November 2014 (open access Journal http://www.rsisinternational.org/IJRSI.html

Moshkin, V. A ., (Ed.) 1986. Castor. Amerind Publishing Co. PVT Ltd. New Delhi.

Ogunniyi, D. S., 2006. Castor oil: a vital industrial raw material. Bioresour. Technol. 97, 1086-1091.

Popova, G. M., 1930. Castor Oil Plant. Leningrad Academy of Agricultural Sciences, Institute of Applied Botany and New Culture, Leningrade.

Prasad, Y.G., Anjani, K., 2001. Resistance to serpentine leafminer, *Liriomyza trifolii* (Burgess) in castor (*Ricinus communis* L.). Ind. J. Agric. Sci. 71, 351-352.

Radhamani, T., Ushakumari, R., Amudha, R., Anjani. K. 2012. Response to water stress in castor (*Ricinus communis* L.) genotypes under in vitro conditions. J. Cereals and Oil seeds. 3, 56-58.

Reddy, A.V. P., Anjani, K., Manikyam, M., 2002. Collecting castor (*Ricinus communis* L.) landraces from Tamil Nadu, India. Pl. Genet. Resour. Newsletr. 132, 60-62.

Sarada, C., Anjani K.2013. Establishment of castor core collection utilizing Self-Organizing Mapping (SOM) networks. J Indian Society of Agricultural Statistics. 67(1):71-78.

Sunil, N., Ashok Kumar, A., Ashokavardhan Reddy, P., Varaprasad, K. S., 2007. Collection of diversity in Castor (*Ricinus communis* L.) germplasm from parts of Andhra Pradesh. Ind. J. Pl. Genet. Resour. 18, 187-190.

Webster, G. L., 1994. Synopsis of the genera and suprageneric taxa of Euphorbiaceae. Ann. Missouri Botanical Garden, 81, 33-144.

ANNEXURE-I

16. Details of centre-wise utilization of castor germplasm

Table 1. Castor germplasm utilization at S. K. Nagar

Germplasm	Crosses made using germplasm	Germplasm utilized for
RG-27	Crossed with DPC-9, SKP-84, Geeta	Development of high TDM lines
RG-49	(VP-1 x RG-49) x VP-1	Development of wilt resistant lines
RG79	SKP-60x RG79	Development of high yield pistillate line
RG79	SKP-1x RG79	Development of high yield pistillate line development
RG-79	SKP 60 x RG79	Development of wilt resistant, high yield pistillate line
RG-109	SKP-72 x RG109	Development of wilt resistant pistillate line
RG-111	Crossed with DPC-9, SKP-84, Geeta	Development of high TDM lines
RG-124	Geeta x (Geeta x RG-124)	Development of wilt resistant lines
RG-293	VP-1 x (VP-1 x RG-293)	Development of wilt resistant lines
RG 390	RG 390 x SKI- 180	Developed a male line, SKI-344
RG 392	SKP 93 x RG 392	Developed an inbred line, SKI-314
RG 392	SKP 35 x RG 392	Developed an inbred, SKI-325
RG-392	SKP-35 X RG-392	Developed an inbred line SKI-303
RG-675	VP- I x RG-675	Development of pistillate line
RG-675	SKP-72 x RG-675	Diversification of pistillate line
RG-675	SKP-76 x RG-675	Diversification of pistillate line
RG-737	SKP-60 x RG-737	Developed an inbred line, SKI-294
RG-1153	RG-1153 (EC 38538)	As a female parent
RG- 1601	RG- 1601 x (VI-9 x TMV-5)	Development of short duration and medium duration varieties with high seed yield and oil content and possessing resistance against various diseases and insect pests.
RG- 1611	RG- 1 611 x (VI-9 x TMV-5)	-do-
RG- 1633	RG- 1633 x (Geeta x TMV-5)	-do-
RG-1647	Crossed with eight pistillate lines	Fresh crossing programme
RG- 1672	RG- 1672 x (SPS-43-3 x 1 16-1)	Fresh crossing programme
RG-1673	Crossed with DPC-9, SKP-84, Geeta	Development of high TDM lines
RG- 1772	RG- 1772 x (48-1 x 2-73- 1 I)	Fresh crossing programme
RG-1921	VP-1 x (VP-1 x RG-1921)	Development of wilt resistant lines
RG-1950	Geeta x (Geeta x RG-1950)	Development of wilt resistant lines
RG-1968	(VP-1 x RG-1968) x VP-1	Development of wilt resistant lines
RG-2375	Crossed with eight pistillate lines	Fresh crossing programme
RG-2787	Crossed with eight pistillate lines	Fresh crossing programme
RG-2819	Crossed with eight pistillate lines	Fresh crossing programme
RG-3242	Crossed with eight pistillate lines	Fresh crossing programme
RG-3291	Crossed with eight pistillate lines	Fresh crossing programme

Table 2. Castor germplasm utilization at IIOR, Hyderabad

Germplasm	Crosses made using germplasm	Germplasm utilized for
RG-272,RG-557, RG-567,RG-1594, RG-1625,RG-1627, RG-1633	21 crosses with 3 pistillate lines	Development of early and medium maturity stable pistillate lines possessing resistance against wilt, and sucking pests.
RG-557,RG-567, RG-1594,RG-1625,RG-1627, RG-1633	60 crosses were made by crossing them to 11 pistillate lines *viz.*, NES-6, DPC-9, DPC-11, LRES-17, M-568, M-571, 591, VP-1, REC-116, SKP-1	Development of early/medium duration high yielding male lines with resistance to wilt and sucking pests.
RG-1740	RG1740 x DCS-25	Botrytis tolerant
RG-1740	RG1740 x DCS 59	Botrytis tolerant
RG-1771	RG1771 x DCS-25	leafminer resistant
RG-1771	RG1771 x DCS-59	leafminer resistant
RG-1771	DCS-25 xRG1771	leafminer resistant
RG-1771	DCS-59 x RG1771	leafminer resistant
RG-1740	DCS-25 X RG1740	Botrytis tolerant
RG-1740	DCS-59 x RG1740	Botrytis tolerant
RG- 47,RG-71, RG- 297, RG-650, RG- 707, RG-149, RG-1404, RG-1442, RG-1471, RG-1647, RG-16848, RG-1713, RG-1719, RG-1726	30 male x male crosses	Development of wilt/botrytis resistant inbred lines
RG -47, RG-71, RG- 297, RG-650, RG-1713, RG-1719, RG-1726, RG-1741, RG-1938, RG-1941	50 female x female crosses	Incorporation of wilt resistance in pistillate/female lines
RG-1954, RG-2040, RG-2127, RG-2178, RG-2377, RG-2445, RG-2529, RG-2559, RG-2602, RG-2612, RG-2661	50 fresh crosses were using the germplasm and 9 pistillate lines	to develop new pistillate lines
RG-1741	DCS 9 x RG 1741	To develop Botrytis resistant inbred lines
RG-1938	DCS 9 x RG 1938	To develop wilt resistant inbred lines
RG-1941	DCS 12 x RG 1941	To develop wilt resistant inbred lines
RG-1954	DCS 12 x RG 1954	To develop wilt resistant inbred lines
RG-1741	DCH 171 x RG 1741	To develop wilt and Botrytis resistant inbreds
RG-1954	DCH 171 x RG 1954	To develop wilt and Botrytis resistant inbred c
RG-1404	DPC 9 x RG-1404	Utilized for diversification of wilt resistance
RG-1713	DPC 9 x RG-1713	To develop wilt and Botrytis resistant inbred lines
RG-1719	DPC 9 x RG-1719	To develop wilt and Botrytis resistant inbreds
RG-1404	DPC 10 x RG-1404	To develop wilt resistant inbred lines
RG-1713	DPC 10 x RG-1713	To develop Botrytis resistant inbred lines
RG -47, RG -71, RG- 297, RG-650, RG- 707	15 crosses were made with 3. pistillate lines *viz.*, DPC 10, DPC 12, DPC 13	Development of wilt resistant new pistillate lines
RG-707	DPC 12 x RG-707	To develop *Fusarium* wilt resistance and papaya leaf type male lines
RG-1404	DPC 12 x RG-1404	To develop *Fusarium* wilt resistance and papaya leaf type male lines
RG-1442	DPC 12 x RG-1442	To develop *Fusarium* wilt resistance and papaya leaf type male lines
RG-707	DPC 13 x RG-707	To develop wilt resistant male lines
RG-1404	DPC 13 x RG-1404	To develop wilt resistant male lines
RG-1442	DPC 13 x RG-1442	To develop wilt resistant male lines
RG-1463	DPC 13 x RG-1463	To develop wilt resistant male lines
RG-1463	DCH 149 x RG-1463	To develop high yielding wilt resistant male lines
RG-1938	DCH 149 x RG-1938	To develop high yielding wilt resistant male lines
RG-1941	DCH 149 x RG-1941	To develop high yielding wilt resistant male lines
RG-1954	DCH 149 x RG-1954	To develop Botrytis resistant male lines
RG-2040	DCH 149 x RG-2040	To develop Botrytis resistant male lines
RG-1463	DCH 171 x RG-1463	For diversification of Fusarium wilt resistance
RG-1938	DCH 171 x RG-1938	For diversification of Fusarium wilt resistance
RG-1941	DCH 171 x RG-1941	For diversification of Fusarium wilt resistance
RG-2127	DCH 171 x RG-2127	For diversification of Fusarium wilt resistance
RG-2040	DCH 171 x RG-2040	To develop Botrytis resistant male lines
RG-1463	GCH6 x RG-1463	To develop wilt and root rot resistant male lines
RG-1938	GCH6 x RG-1938	To develop wilt and root rot resistant male lines
RG- 2178	GCH 6 x RG- 2178	To develop wilt and root rot resistant male lines
RG-1954	GCH 6 x RG-1954	To develop Botrytis & root rot resistant male line

RG-204	GCH6 x RG-204	To develop Botrytis & root rot resistant male line
RG-707, RG-1442, RG- 1463	6 crosses were made with pistillate lines, M 571, M 574	Diversification of wilt resistant pistillate lines
RG-1647,RG-1648	Four crosses were made with pistillate lines, M584,M619	Diversification of wilt resistant pistillate lines
RG-1954, RG-1741	Four crosses were made with pistillate lines, M 571, M 574	Development of Botrytis resistant pistillate lines
RG- 297	DCH 827 x RG- 297	To incorporate wilt resistance
RG 2779, RG-2855,RG- 2850, RG-224, RG-2787	Five Crosses were made with female parent Kranti	To incorporate Botrytis resistance
RG-297	DCH 888 x RG-297	To incorporate wilt resistance in diverse pistillate background
RG-1726	DCH 922 x RG-1726	To incorporate wilt resistance in diverse pistillate background
RG 297	Rb-06-1457 x RG-297	To develop wilt resistant inbred lines
RG2724, RG-1719, RG-2718	RG2724, RG-1719, RG-2718	
RG- 297	(VP-1 x RG-297) x RG-297	To incorporate pistillate in diverse wilt resistance background
RG- 297	(VP- 1 x RG-297) x VP-1 (VP-I x RG-297) x RG-297 VP- 1 x R-297	To study genetics of wilt resistance and to develop wilt resistant inbred lines
RG 3020, RG 3055, RG 3066, RG 3105, RG 3174	10 crosses were made with DPC9, 48-1	To generate breeding material with high oil and seed weight
RG-1659	RG-1659 x M 619	Made selections from the segregating generations for high yield components, pistillatness, wilt resistance, bold seed and capsules, long spikes, very long spikes
RG-1659	RG-1659 x DCS 94	
RG-1659	RG-1659 x DCS 96	
RG-2612	DPC9 x RG-2612	
RG -47	DPC I0 x RG -47	
RG-1442	DPC I0 x RG-1442	
RG-2377	DPC 10 x RG-2377	
RG-761, RG-799, RG -1155, RG-1163, RG-1172,RG -1581, RG-1582, RG-2444, RG-2445, RG-2451, RG-2452, RG-2672, RG-2991	Crossed with pistillate lines, M 574, DPC 16, DPC 17 and DPC 9	To generate diverse pistillate lines
35 USDA accn.		For inbred lines development
RG-1442	DPC- 10 x RG-1442	Development of high yielding, wilt resistant male lines
RG-1471	DPC- 10 x RG-1471	Development of high yielding, wilt resistant male lines
RG-297	DPC-9 x RG-297	Development of high yielding, wilt resistant male lines
RG-1713	DPC-9 x RG-1713	Development of high yielding, wilt resistant male lines
RG-799	DPC-9 x RG-799	To develop new pistillate lines
RG-2991	DPC-9 x RG- 2991	To develop new pistillate lines
RG-1582 (G)	DPC-16 x RG-1582 (G)	To develop new pistillate lines
RG-2452	DPC-16 x RG-2452	To develop new pistillate lines
RG-2672	DPC-16 x RG-2672	To develop new pistillate lines
RG-799	DPC 17 x RG-799	To develop new pistillate lines
RG-1155	DPC- 17 x RG-1155	To develop new pistillate lines
RG-1582-2	Crossed to pistillate lines	To develop experimental hybrids
	Rb0 1-1522x RG-1463	To develop botrytis resistant male lines
RG-297	[(DPC-9x RG-297) x (M574-1/RG-71)],	For developing high yielding male lines
RG-71	[(DPC-9x RG-297) x (M574-1/RG-71)]	For developing high yielding male lines
RG-297	(DPC-9x RG-297) x DCH- 1053)	For developing high yielding male lines
RG-297	(DPC-9x RG-297) x DCH- 1053)	For developing high yielding male lines
RG-156, RG-404, RG-1740A, RG-2661	Crossed to pistillate lines	Used in generation of experimental hybrids
RG- 1740/A	[(SKI-291 x RG- 1740/A) x (SKI-217 x DCS- 120)]	To generate diverse breeding lines
RG-404/B	(DPC-9 x RG-404/B) x (SKI-291 x Narkhoda local)	To generate diverse breeding lines
RG-156	(M-619 x RG-156) x DCS-107	To generate diverse breeding lines
RG-3020	DCS-9 x RG-3020	To generate high oil, high yielding and Botrytis

		tolerant breeding lines
RG-3020	48-1 x RG-3020	To generate high oil, high yielding and Botrytis tolerant breeding lines
RG-3020	DCS-9 x RG-3020	for incorporating bold capsule trait
RG-3066	DCS-9 x RG-3066	for incorporating bold capsule trait
RG-3105	48-1 x RG-3105	For incorporating initial yellow and later pink capsules
RG-297	(DCS-9 x RG-297) x (DPC-13 x RG-297)	To develop early to medium duration (10-15 nodes), long spike, pistillate, wilt resistant inbred lines
RG-404/B	(JI-227 x RG-404/B) x DCS-84	To generate diverse breeding material
RG- 1740/A	(DPC-9 x RG- 1740/A) x RG- 1740/A (JP-88 x RG-404/B) x RG-404/B (JP-87 x RG-1740/A) x M-574	to develop diverse pistillate line
	(SKI-291 x RG- 1740/A)x Ethiopian collection	To enhance the genetic diversity of the male lines
RG-3174	48-1 x RG-3174	To generate very early (7-8 nodes) lines
RG-1582 (R)	Geeta x RG-1582 (R)	To generate high yielding breeding lines
RG-1614	M-574 x RG-1614	To incorporate high pistillate trait
RG-1614	DPC-17 x RG-1614	To incorporate high pistillate trait
RG1740/A	(SKI-291 x RG1740/A) x (SKI-217 x DCS-120)	To develop diverse male lines
RG1740/A	(SKI-217 x DCS-120) x (SKI-291 x RG1704/A)	To develop diverse male lines
RG404/B	(DPC-9 x RG404/B) x (SKI-291 x Narkhoda local)	To develop diverse male lines
RG404/B	(SKI-291 x Narkhoda local) x (DPC-9 x RG404/B)	To develop diverse male lines
RG1740/A	(SKI-291 x RG1740/A)	To develop diverse male lines
RG-3020	DCS-9 x RG-3020	To develop high yielding Botrytis tolerant male lines
RG-3174	48-1 x RG-3174	To develop high yielding Botrytis tolerant male lines
RG1740/A	(SKI-291 x RG- 1740/A)	To incorporate high yield
RG-156	SKI-217 x RG-156	To incorporate early maturity and low node number
RG-3020	SKI-291 x RG-3020	To incorporate long productive spike trait
RG-3354	Crossed with M-619 and M-574	For pistillate line development
RG-27, RG-72, RG-111, RG-298, RG-1494, RG-2139	Crossed with pistillate line DPC-9	Development of new pistilalte lines with drought tolerance, good root traits, double/triple bloom
RG-1354, RG-2874	RG-1354 × RG-2874	To develop 'marker tool kit' for wilt resistance breeding in castor
RG-2681, RG-1673	RG-2681 × RG-1673	
RG-999	RG-999 × JI-35	-do-
RG-2685, RG-2681	RG-2685 × RG-2681	-do-
RG-1673, RG-2874	RG-1673 × RG-2874	-do-
RG-1999	RG-1999 × JI-35	-do-
RG-1963		
RG-1963, RG-3088	[(CI-1 × CI-2) × (RG-1963 × RG-3088-1)], [RG-1963 × RG-3088-1) × (M574 × CI-2)], [(CI-1 × CI-2) × (SKP84 × RG3088-1)], [(SKP84 × RG-3088-1) × (RG-1963 × RG-3088-1)], [(SKP84 × CI-2) × (RG1963 × RG3088-1)]	For creating base population for development of inbred lines resistant to gray mold
RG-558	[(RG-1963 × RG-3088-1) × (RG-1963 × RG-558-1), [(RG-1963 × RG-558-1) × (CI-1 × CI-2)], [(RG-1963 × RG-558-1) × (M574 × CI-2)], (SKP84 × RG-3088-1) × (RG-1963 × RG-558-1)], [(RG-1963 × RG-558) × (SKP84 × CI-2)]	-do-
RG-999	PMC13 × RG-999-1, PMC53 × RG-999-1	For improving wilt resistance in elite inbred lines
RG-999, RG-1149		For developing backcross populations towards NIL
RG-1354,RG-2874, RG-1673, RG-2874, RG-2681, RG-1673, RG-2685, RG-2681	RG-1354 × RG-2874, RG-1673 × RG-2874, RG-2681 × RG-1673, RG-2685 × RG-2681	For establishing gene diversity for wilt resistance and develop gene specific near isogenic lines.

Table 3. Castor germplasm utilization at Junagadh

Germplasm	Crosses made using germplasm	Germplasm utilized for
RG-154, RG-1591, RG-1598, RG-1625, RG-1633, RG-1611	28 fresh crosses with 5 pistillate lines *viz.,* SKP-72, SKP-13, SKP-16, JP-65, JP-75	To develop early and medium maturing high yielding varieties with resistance to wilt
RG-154	JP-65 x RG-154	Development of early, high yielding male lines
RG-1625	JP-75 x RG-1625	Development of wilt resistant, bold seed, high yield male lines.
RG-1611	JP-75 x RG-1611	Development of high yield, high oil male lines
RG-1598	SKP13 x RG-1598	Development of wilt and leafhopper resistant, high yielding male lines
RG-154	SKP-72 x RG-154	Development of early, high yielding male lines
RG109	SKP-72 x RG109	Development of wilt resistant male lines
RG-675	VP- I x RG-675	Utilized in pistillate line development
RG-79	SKP-60 x RG-79	Development of high yielding male lines
RG-79	SKP-1x RG-79	Development of high yielding male lines
RG-675	SKP-72 x RG-675	Utilized in pistillate line development
RG-675	SKP-76 x RG-675	Utilized in pistillate line development
RG-1625, RG-1611, RG-1598, RG-154, RG-79	20 crosses with 4pistillate lines	To develop early, high yielding, wilt resistant pistillate lines
RG-79	SKP60 x RG-79	Developed the new pistillate line, JP-89
RG-79	SKP-60 x RG-79	Developed a new pistillate line, JP-93
RG-2787	(JP-105 x SKI-215) x RG-2787	Development of wilt and root rot resistant male lines
RG-2787	JP-105 x JI-368) x RG-2787	Development of wilt and root rot resistant male lines
RG-2787	5 Crosses with 5 pistillate lines	To generate new breeding lines
RG-3533	RB-2 x RG-3533	Development of short & medium duration high yielding, root rot / wilt disease resistant male lines
RG-3535	RB-2 x RG-3535	Development of short & medium duration high yielding, root rot / wilt disease resistant male lines
RG-3041	RB-2 x RG-3041	Development of short & medium duration high yielding, root rot / wilt disease resistant male lines
RG-3073	SKI-387 x RG-3073	Development of short & medium duration high yielding, root rot / wilt disease resistant male lines
RG-3073	GP-95 x RG-3073	Development of short & medium duration high yielding, root rot / wilt disease resistant male lines
RG-3073	RG-3533 x RG-3073	Development of short & medium duration high yielding, root rot / wilt disease resistant male lines
RG-2826	JP-96 x (SKP-84 x RG-2826)	Development of short & medium duration, high yielding, root rot / wilt disease resistant male lines
RG-2787	Chain crossed with 4 inbred lines	Used in genepool development
RG-43	JI-423 x RG-43	Development of diverse early maturing, leafhopper resistant high yielding inbred lines
RG-43	JI-426 x RG-43	Development of diverse early maturing, leafhopper resistant high yielding inbred lines
RG-43	JI-434 x RG-43	Development of diverse early maturing, leafhopper resistant high yielding inbred lines
RG-3073	JI-434 x RG-3073	Development of diverse early maturing, leafhopper resistant high yielding inbred lines
RG-1647,RG-2375, RG-2787, RG-2819, RG-3242, RG-3291	Crossed in L x T with 5 pistillate lines *viz.,* JP-89, JP-106, JP-65, JP-96, JP-104	To study combining ability of germplasm accessions
RG-27, RG-111	Crossed with 6 pistillate lines *viz.,* JP-69, JP-89, JP-96, JP-101, JP-104, JP-106	Development of high TDM lines

Table 4. Castor germplasm utilization at Mandor

Germplasm	Crosses made using germplasm	Germplasm utilized for
RG-22	RG-22 x DCS-9	As donor for extra-early maturity
RG- 675	RG- 675 x DCS-9	As donor for early maturity
RG-1771	TMV-5 x (48-1x RG-1771)	As donor for leafminer resistance
RG-1771	JI-106 x (48-1 x RG-1771)	As donor for leafminer resistance
RG-1771	MI-63 x (48-1 x RG-1771)	As donor for leafminer resistance
RG-1771	MI-60 x (48-1 x RG-1771)	As donor for leafminer resistance
RG-1771	MI-61 x (48-I x RG-1771)	As donor for leafminer resistance
RG-1771	JI-122 x (48-1x RG-1771)	As donor for leafminer resistance
RG-125-1, RG-1686	(RG-125-1 x RG-1686) x RG-125-1	to develop wilt resistant, earliness and bold seeded high yielding male combiners
RG-125-1, RG-2350, RG-1268	(RG-125-1 x RG-2350) x RG-1268	to develop wilt resistant, earliness and bold seeded high yielding male combiners
RG-1686	(MP RHC 14 x RG-1686) x RG-1686	to develop wilt resistant, medium duration high yielding male combiners
RG-1686	(MP RHC 14 x RG-1686) x MP RHC 14	to develop wilt resistant, medium duration high yielding male combiners
RG-1686	(STV 4-00 x RG-1686) x STV-4-00	to develop wilt resistant, medium duration high yielding male combiners
RG-1686	(GC 2 x RG-1686) x GC 2	To develop bold seeded wilt resistant inbred lines
RG-1686, RG-1268	(STV 4-00 x RG-1268) x RG-1686	To develop bold seeded wilt resistant inbred lines
RG-1686	(GC 2 x RG-1686) x RG-1686	To develop bold seeded wilt resistant inbred lines
RG-1686, RG-125-1, RG-2350	(RG-125-1 x RG-2350) x (RG-125-1 x RG-1686)	To develop bold seeded wilt resistant inbred lines
RG-1268	RG-1268 x RG-125-1) x (RG-125-1 x RG-1268)	To develop bold seeded wilt resistant inbred lines
RG-1686, RG-125-1	(MI 61 x RG-1686) x (RG-125-1 x RG-2350)	To develop bold seeded wilt resistant inbred lines
RG-1686	MCP1-1 x (MCPI-1 x RG-1686)	To develop wilt resistant, bold seeded pistillate line
RG-1686	VP 1 x (VP 1 x RG-1686)	To develop wilt resistant, bold seeded pistillate line
RG-1686	(VP 1 x JI 120) x (VP 1 x RG 1686)	To develop wilt resistant ,bold seeded pistillate line
RG-1686, RG-125-1	(VP 1 x RG-1686) x (RG-125-1 x RG 1686)	To develop wilt resistant, bold seeded pistillate line
RG-1686, RG-125-1, RG-1268	RG-125-1 x (RG-125-l x RG-1686), (RG-1686 x RG-125-1) x (RG-125-1 x RG-1268)	to develop wilt resistant, early varieties/male lines with high seed yield and oil contend
RG-1686	STV 4-00 x RG-1686	As donor for wilt resistance
RG-1686	VP-1 x RG-1686	As donor for wilt resistance
RG-1686, RG-125-1	RG125-1 x RG-1686	As donor for wilt resistance to develop new pistillate line
RG-125-1	(Geeta x RG-125-1) x MP19-05	to develop early duration, drought tolerant, wilt resistant inbred lines
RG-125-1	(Geeta x RG-125-1) x MP29-05	to develop medium duration, drought tolerant, wilt resistant,high seed yield inbred lines
RG-125-1	(Geeta x RG-125-1) x MP21-05	to develop early, bold seed, drought tolerant, wilt resistant inbred lines

Table 5. Castor germplasm utilization at Palem

Germplasm	Crosses made using germplasm	Germplasm utilized for
RG-22	VP-1 x RG-22	As donor for early maturity and low node number
RG2718	Kranti x RG2718	As donor for wilt resistance
RG 1719	Kranti x RG 1719	As donor for wilt resistance
RG 2724	Kranti x RG 2724	As donor for wilt resistance
RG 1719	Aruna x RG 1719	As donor for wilt resistance
RG-224	Haritha x (Kranti x RG-224)	As donor for wilt resistance
RG-2787	RG 2777 x (Kranti x RG 2787)	As donor for wilt, root rot , Botrytis resistance
RG-2752	Aruna x (Aruna x RG-2752)	As donor for wilt, root rot resistance
RG-2787	RG 2787 x (Kranti x Haritha)	As donor for wilt, root rot, Botrytis resistance
RG-2855	PCS 122 x RG-2855	As donor for wilt,Botrytis resistance, high yield
RG-2833	PCS 138 x RG-2833	As donor for wilt and Botrytis resistance
RG-2088	Haritha x RG-2088	As donor for wilt and Botrytis resistance
RG-2377	Kranti x RG-2377	As donor for wilt and Botrytis resistance
RG -713	Haritha x RG -713	As donor for wilt and Botrytis resistance
RG-2844	PCS122 x RG-2844	As donor for wilt and Botrytis resistance
RG -713	Kranti x RG -713	As donor for wilt and Botrytis resistance
RG-2327	Kranti x RG-2327	As donor for wilt and Botrytis resistance
RG-1827	Kranti x RG-1827	As donor for wilt and Botrytis resistance
RG-297	(VP-1 x RG-297) x RG-297	As donor for wilt resistance in pistillate line
RG-2752	Kranti x RG-2752	For male line development
RG-29	Kranti x RG-29	For male line development
RG-1417	Kranti x RG-1417	For male line development
RG-1504	Kranti x RG-1504	For male line development
RG-1648	Kranti x RG-1648	For male line development
RG-109	Kranti x RG-109	As donor for wilt resistance
RG-14-2	DPC-9 x RG-14-2	For developing high yielding male lines
RG-14-2	Used in crossing	For male line development
RG-18	Used in crossing	For male line development
RG-18-1	M-574 x RG-18-1	As donor for early maturity
RG-14-2	VP-1 x RG-14-2	To incorporate extra-early maturity
RG-14-2	VP-1 x RG-14-2	Development of monoecious lines
RG-18-1	M-564 x RG-18-1	Development of monoecious lines
RG-28-1	M-574 x RG-28-1	Development of mono spike monoecious lines
RG-27	Crossed with 4 pistillate lines *viz.*, PPL-9, M-574, DPC-9, JP-96	Development of high TDM lines
RG-111	Crossed with 4 pistillate lines *viz.*, PPL-9, M-574, DPC-9, JP-96	To develop diverse pistillate lines with high TDM

Table 6. Castor germplasm utilization at Bawal, Kanpur, Hiriyur, Navasari, Bhavanipatna, Anand and Yethapur

Centre	Germplasm	Crosses/accessions	Utilization
Bawal	RG-297	Rb-05-1451 x RG297	To develop wilt resistant inbred lines
	RG-297	Rb-05-1457 x RG297	To develop wilt resistant inbred lines
Kanpur	RG-17,RG- 19, RG-3134, RG -2446	24 crosses were made with T-3, Tarai-4, Baliya Selection, Chandraprabha and Kalpi-6	To develop early maturing high yielding male lines
	RG-3203	Used in crossing programme	To incorporate high yielding in new pistillate lines
	RG-3191	Used in crossing programme	To incorporate early maturity in new pistillate lines
	RG-3221	Used in crossing programme	To incorporate high number of capsules/spike in new pistillate lines
	RG-3101	Used in crossing programme	To incorporate high seed weight in new pistillate lines
	RG-2822	Used in crossing programme	To incorporate wilt and root rot resistance in new pistillate lines
	RG-3202	DPC9 x RG-3202	New experimental hybrid
	RG-3202	DCS105 x RG-3202	New experimental hybrid
	RG-3202	DCS105 x RG-3202	New experimental hybrid
	RG-3209	DCS106 x RG-3209	New experimental hybrid
	RG-3202	DCS 107 x RG-3202	New experimental hybrid
	RG-3202	M571 x RG-3202	New experimental hybrid
	RG-3209	M571 x RG-3209	New experimental hybrid
	RG-2787	DPC16 x RG-2787	New experimental hybrid
	RG-3209	DPC16 x RG-3209	New experimental hybrid
Hiriyur	Extra-early genepool	Extra-early genepool	To select promising early maturing lines
	RG-607	Used in crossing programme	To incorporate early flowering
	RG-3307	Used in crossing programme	To incorporate low number of nodes
Navasari	RG-3561	Used in crossing programme	To incorporate compact spike, high yield
	RG-3568	Used in crossing programme	To incorporate profuse branching, dwarf and early maturity traits
	RG- 631	Used in crossing programme	To incorporate bold capsules, compact spike traits
	RG-3041	ANDCP8-1 x RG-3041	New experimental hybrid
	RG-3561	ANDCP8-1 x RG-3561	New experimental hybrid
	RG-3568	SKP-84 x RG-3568	New experimental hybrid
	RG-3020	Used in crossing programme	Development of high yielding wilt resistant monecious lines
	RG-43	RG-43 xGP-664 RG-43 x GP-705 RG-43 x JP-2	
	RG-2822	RG-2822 xGP-664 RG-2822 x GP-705 RG-2822 x JP-2	
Bhavanipatna	RG-22, RG-43, RG-47, RG-155, RG-3832	crossed with 7 pistillate lines	Development of male combiners
Anand	RG-3938, RG-3963, RG-3748	Crossed with 7 pistillate lines	Development of high yielding inbred lines
	RG-2194	SKP-84 x RG-2194	For generation of new hybrids
	RG-2364	SKP 84 x RG-2364	For generation of new hybrids
	RG-3963	SKP-84 x RG-3963	For generation of new hybrids
	RG-3964	SKP-84 x RG-3964	For generation of new hybrids
	RG-3533	SKP-84 x RG-3533	For generation of new hybrids
	RG-2194	ANDCI 10-5 x RG-2194	Development superior monoecious lines
	RG-2194	ANDCI 10-5 x RG-2194	Development superior monoecious lines
Yethapur	RG-27, RG-111, RG-1673	Crossed with 4 pistillate lines *viz.*, DPC-9, M-574, SKP-84 and Geeta	Development of high TDM lines
	RG-43	DPC-9 x RG-43	Development of new pistillate lines