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ENTRAPMENT OF THE GENETIC DIVERSITY OF PERENNIAL CASTOR (*RICINUS COMMUNIS* L.) IN NORTHEAST INDIA

Aftab A. Shabnam[1]*, Amit Kumar[2], Priyanka Sahu[1], D.K. Jigyasu[1] and K.M. Vijaya Kumari[1]
[1]Central Muga Eri Research & Training Institute, CSB, Lahdoigarh, Jorhat-785700, Assam, India
[2]Central Sericultural Research & Training Institute, CSB, Mysuru- 570 008, Karnataka, India
*Corresponding author: aftab.csb@gov.in

ABSTRACT

Castor (*Ricinus communis* L.) is the main host plant of eri silkworm (*Samia ricini* D.) and Eri silkworm rearing on castor is desirable for basic seed production and to get the highest potential yield. In India, castor is contributing chiefly in the production of the Eri silk. However, the annual nature of castor has limited its spread in the field due to involvement of annual recurring cost for raising systematic plantations as well as deficient leaf availability during early growth period. Perennial castor will not only minimize the input cost but will also ensure the leaf availability throughout the year. Vast diversity of wild un-adopted perennial castor plants exists in North East India. Keeping this in view, the present investigation is focused to target the natural perennial germplasm collection from the northeastern region of India (61–1573m AMSL). The rigorous expedition for collection of the germplasm was attempted during the period 2019-2021. All the collected perennial germplasm was evaluated at Central Muga Eri Research and Training Institute, Lahdoigarh, Assam. Total 73 descriptor characters were analyzed in the 12 promising perennial castor germplasm. Variability in perennial source accessions ranged from 10.15 to 40.70% with highest variability in total shoot length. The dominance characters i.e. erect habit (75%), red stem color (33%), incised lobe shape (100%), convergent branching (58%), non-bloomy (83%), tristichous phyllotaxy (58%), mucronate type leaf apex (59%), Coriacious leaf texture (50%), Non glossy leaf (50%), leaf surface roughness (50%), Red mature stem color (83%), anthocyanin pigmentation (33%), staminate flowers presence on the lower part of the Raceme (92%), intermediate type of raceme density (83%) and non-dehiscent fruit (92%) was observed. Variability in morpho-metric, biochemical and bioassay traits in perennial castor is discussed.

***Keywords* :** Perennial castor, *Ricinus communis*, genetic diversity, variability.

Introduction

Eri culture plays significant role in rural livelihood security especially among marginalized and weaker sections of the society. All operations from rearing to weaving are done mostly by women folk. Thus, it has attracted maximum attention of the rural people in North Eastern region of India and is practiced as spare time occupation by the women folk. Eri silkworm (*Samia ricini*) is polyphagous in nature and its feeding behaviour on several plant species has been examined by many workers and based on the preferred food, host plants have been listed as primary (*Ricinus communis* and *Heteropanax fragrans*), secondary (*Ailanthus grandis, Manihot esculanta, Evodia flaxinifolia* and *Ailanthus excelsa*) and tertiary (*Ailanthus glandulosa, Ailanthus tryphysa, Carica papaya, Gmelina arborea*) (Anonymous, 2010). Castor (*Ricinus communis* L.) is an important primary food plant among these plants (Tikader and Kamble, 2010). Rearing of Eri silkworm on castor is desirable for basic seed production and to get the highest potential yield (Chutia *et al.*, 2017). However, its annual nature has limited its spread in the field due to involvement of annual recurring cost for raising systematic castor plantations. A lot of work for the genetic improvement of castor vis-à-vis its seed and oil yield has been carried out in India and rest of the world. However, limited work has been carried out for the genetic improvement of castor with regard to biomass and habit of the plant. High yielding non-blooming castor varieties such as NBR-1, NBR-2 and NBR-3, selected out of evaluation trials have shown promising results in Eri culture (Sarmah and Chakravorty, 2008). However, their spread in the farmers' field has remained limited mainly due to their annual nature. Therefore, it is desirable to evolve a perennial castor cultivar to make it economically viable so that the farmers can raise their own castor plantations. Technology for growing annual NBR-1 castor as perennial has been developed by altering various agronomical practices (Sarmah *et al.,* 2008). However, these perennials have successfully grown only for 2-3 years. The genetic improvement for developing a perennial castor plant has not been attended to.

Castor (*Ricinus communis* L., 2n = 2x = 20) is a monotypic species belonging to the Euphorbiaceae family and favours cross-pollination up to the extent of 50% due to its monoecious nature (Allan *et al.*, 2007). The plants can be self- or cross-pollinated by wind, with out-crossing as predominant mode of reproduction (Meinders and Jones 1950; Brigham 1967). Therefore, vast diversity in the genetic stocks has crept in owing to its crossing behaviour. The diversity in the wild and gene banks can be utilized to evolve a desirable castor cultivar for sustainable Eri culture. Plenty of wild un-adopted perennial castor plants are available at various locations in North Eastern states and the collection of these accessions will enrich the castor gene-pool especially with the perennial trait for its future applicability. With this aim the present study was carried out to harness the available perennial castor diversity in the region for conservation and evaluation purposes.

Materials and Methods

Exploration and collection

North East region, which is rich in diversity of sericigenous insects and their host plants, was extensively surveyed for the collection of Eri host plant. During the collection the focus was mainly on castor (the important primary eri host plant) with emphasis on perennial castor plants. Geographical coordinates and digital data of collection sites was recorded for geo-positioning and virtual mapping of all the sources and sites (Fig. 1 & Table-1). Seeds of identified wild perennial castor plants growing in isolation were harvested and collected. Perennial castor plants were selfed, wherever required, and selfed seed was harvested and collected. Passport data of the collections was also recorded.

Evaluation

Seeds of 12 collected perennial accessions were sown at CMER & TI, Lahdoigarh and plants showing perennial trait were selfed and pure seeds were harvested. Pure seeds of these perennials were sown in Randomized Block Design (RBD) in three replications with inter and intra row spacing of 1 x 1 meter during March-April 2021. The plantation was maintained as per recommended package of practices (Sarmah, 2004). Data was recorded on 07-08 month old plants during Oct-Nov. 2021.

Castor plant varies greatly in its growth and appearance. It varies in growth habit, colour of foliage, stems, seed size and colour, and oil content, so that varieties often bear little resemblance to one another. Castor may be large perennials often developing into small trees, others behave as short-lived dwarf annuals and every gradation between these extremes can be found. Morphological characterization was carried out based on visual observations and supported by quantitative measurements where ever required. Bioassay studies were carried out on Borduar ecorace in three replications during Oct-Nov season. 10 DFLs/replication were brushed and 100 larvae were retained in each replication after 3rd moult.

Standard protocols for characterization reported by Sahay *et al.* (2016), Chakravorty *et al.* (2006), Silva *et al.* (2019), Chaudhary *et al.* (2019) and Gogoi *et al.* (2011) with customization wherever required were followed. Total 73 descriptor characters were recorded and data analysis was carried out using Microsoft excel (table 2-5).

Conservation

The conservation and use of genetic resources are the two inseparable components of varietal improvement. Therefore, the seeds of characterized accessions were stored in polypropylena plastic bags (Santoso *et al.*, 2015) and ambient and cold storage techniques as suggested by Anjani and Jatothu (2015) and Pandey and Radhamani (2006) was adopted for short and long term conservation.

Results and Discussion

Morphological traits

Morphological characters are strongly heritable in nature and expected to be visible equally in all the environments and hence used in the genetic identification of the accessions and this also enable an easy and quick discrimination between the phenotypes. Morphological characterization of seed, seedling and plant would generally be considered for varietal identification. Introduction of Plant Variety Protection under General Agreement on Trade and Tariff (GATT) necessitated the need is precise genotypic characterization with clear Distinctiveness (D), Uniformity (U) and Stability (S). The concept of DUS was fundamental for the characterization of the variety as a unique creation. In the present investigation, variability in morphological traits has shown predominance of many characters in the collected germplasm. Red stem colour was more dominant with 33% accessions followed by mahogany in 25% accessions (table 2). According to Shankar *et al.* (2010), red is controlled separately by a single dominant gene. Rodrigues *et al.* (2014) also found variability in stem colour of castor bean, where 66.66% of the accessions evaluated had pink stems. Chaudhary *et al.* (2019) reported mahogany stem colour in 57.69% accessions. Gogoi *et al.* (2011) evaluated 72 castor accessions and reported five different stem colours viz., light green (9.71%), deep green (15.28%), light red (9.72%), dark red (34.72%) and pink (30.56%). Erect habit was recorded in 75% accession supporting the perennial tree nature of these accessions (table 2). Wax coating was not visible in 83% accessions (non-bloom) while as 17% accessions showed triple bloom nature (table 2). Earlier, Silva *et al.* (2019) reported that 87.98% of the castor bean plants had wax. Gogoi *et al.* (2011) has reported 47.22% accessions showing bloom nature. Bloom or waxy coating in castor is an important morphological marker and serves as a natural protection against drought, cold, jassids etc. (Shankar *et al.*, 2010 and Lavanya and Gopinath, 2008). Variation in other characters is recorded in table-2 and is in agreement of the earlier studies carried out by Gogoi *et al.* (2011); Silva *et al.* (2019); Chaudhary *et al.* (2019) and Rodrigues *et al.* (2014).

Metric traits

Castor is a natural crossing plant due to its floral morphology because of which lot of variability has crept in the genetic stocks. The evaluation of the 12 wild and cultivated perennial castor collections using the coefficient of variation (CV%) had limits of 2.58% and 46.15%. These values correspond to leaf moisture content and anthocyanin content, respectively (table 4). The leaf productivity descriptor had a value of 21.17%, total shoot length (40.70%), number of shoots per plant (28.70%) and length of primary receme (14.79%) (Table 3). These values are indicative of quantitative and polygenic nature which are strongly influenced by the environment (Silva *et al.*, 2012 and 2019). Several other authors have also reported variable CV% values for quantitative traits of castor (Sampaio *et al.*, 2011; Bezerra *et al.*, 2010; Fernandes *et al.*, 2015).

Present investigation revealed that plant height of collected accessions ranged from 0.87 to 2.56 m, leaf yield per plant ranged from 0.73 to 1.92 kg and leaf area ranged from 428.61 to 762.40 sq. cm (table 3). The results are in conformity with the earlier works carried out by Govindan *et al*. (2003) who observed a significant variation among castor hybrids/varieties with respect to plant height at different days of sowing. Gogoi *et al*. (2005) studied 22 castor accessions and reported that plant height ranged from 98.00 to 179.67 cm and the leaf yield/plant from 1.50 to 4.55 kg. Shifa (2011) reported maximum plant height of 176.33 cm and stated that plant height, number of leaves/plant and leaf area were significantly greater among the castor genotypes. Sarmah *et al*. (2011) observed growth parameters of eight castor accessions for three consecutive years (2007–2010) and found significant variation among the accessions. Castor hybrids/varieties (GCH-4, GCH-5, 48-1, DCH-519, DCH-177, DCH-32 and Jyothi) were evaluated by Sarmah and Sarkar (2013) for growth and eri silkworm rearing characters in comparison with local variety (NBR-1). Apart from seed production, it is recommended by these authors that these hybrids/varieties can be effectively utilized for eri silkworm rearing as they have enormous potential to generate additional income in both traditional and non-traditional states of India through production of leaf.

Bio-chemical traits

The biochemical composition of the castor leaves significantly contributes in the cocoon production as well as larval health. Hence, it is essential to study the varietal difference in moisture, protein, chlorophyll and other biochemical contents in germplasm. Present investigation has revealed variations in biochemical parameters of 12 perennial castor accessions. However, the variation in important traits like moisture content and moisture retention capacity was low and the CV% values were 2.58 and 7.63, respectively. Variation was highest in anthocyanin content with 46.15% CV. Phenol content (mg/g) ranged from 0.48 to 2.27 (table 4). Earlier, Sarmah *et al*. (2011) observed that the leaf biochemical compositions were significantly different among the accessions. Rao *et al*. (2009) and Anjani *et al*. (2010) reported that high phenol content affected on feeding during larval stage. Sengupta, *et al*. (2008) screened 09 improved varieties of castor and concluded that NBR-1 and Damalgiri Red were nutritively superior varieties and suitable for Gangetic alluvial soil conditions of West Bengal. Anjani *et al*. (2010) established a significant positive association between total phenol content and insect resistance where phenols were known to play an important role in plant defense against harmful insects.

Bioassay traits

Variations in bioassay traits was observed when eri silkworms (Borduar ecorace) were fed with 12 perennial castor accessions. CV% values ranged from 5.70 to 19.24 with highest value attained in pupae weight and lowest in larval duration. Cocoon weight ranged from 2.03 to 5.74 g, shell weight from 0.25 to 0.56 g, pupae weight from 1.74 to 5.29 g and fecundity was 290 to 410 (table 5). Sarmah *et al.* (2011) reported significant variation in larval weight, cocoon weight, shell weight, SR% and ERR% among the accessions. Similar observations are reported by Patil *et al*. (2000) and Jayaramaiah and Sannappa (2000). Prasanna D. and Bhargavi GY (2017) reported significant difference among the five castor genotypes in larval duration, larval weight, silk ratio, ERR, cocoon weight, fecundity, and hatchability. Chaudhary (1979), reported that nutritional value of the feed plays a major role in larval and cocoon parameters. Mani *et al*. (2002) in a study found that there was slight difference in the qualitative characters of amino acids in castor, kesseru and tapioca due to the higher leaf quality, higher rate of food ingestion and food assimilation may also have played a role in higher silk ratio in DCH-519 and local castor genotype

Conclusion

In the current investigation, castor accessions/varieties evaluated showed considerable variations in the growth and yield parameters. The accessions showed striking differences in morphological traits and bioassay studies have indicated non-significant impact on rearing of eri silkworms especially on larval duration and ERR. Therefore, these accessions should be conserved and utilized as potential parents in the future breeding programmes to evolve a productive perennial castor cultivar.

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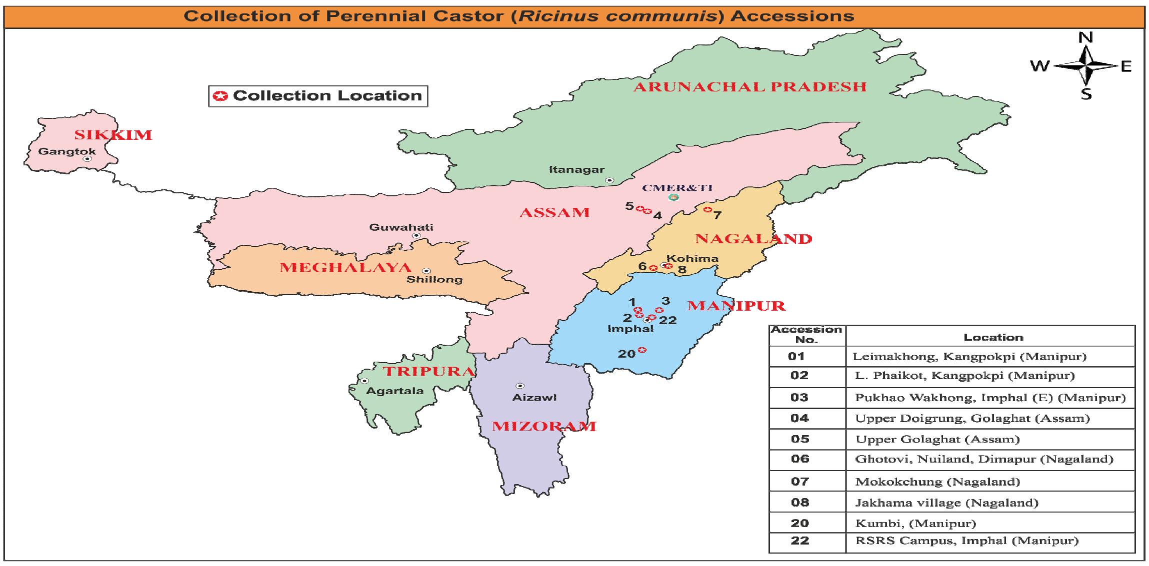

Fig. 1: Collection locations of perennial castor (*Ricinus communis*) accessions

Table 1: Details of 12 Perennial Castor (*Ricinus communis*) Accessions

Perennial Acc. No.	Location	Geographical coordinates	Altitude (m)	Date of collection
01	Leimakhong, Kangpokpi (Manipur)	24º56.3566"N 93º50.0819"E	929	11/12/2019
02	L.Phaikot, Kangpokpi (Manipur)	24º55.9590"N 93º50.1490"E	866	11/12/2019
03	Pukhao Wakhong, Imphal (E) (Manipur)	24º58'9.37"N 94° 2'22.67"E	811	12/12/2019
04	Upper Doigrung, Golaghat (Assam)	26°23'0.60"N 93°47'33.57"E	143	30/05/2019
05	Upper Golaghat (Assam)	26°23'1.33"N 93°47'32.82"E	61	14/02/2019
06	Ghotovi, Nuiland, Dimapur (Nagaland)	25°33'54.18"N 94° 0'21.00"E	433.5	16/03/2019
07	Mokokchung (Nagaland)	26°23'3.54"N 94°26'29.74"E	982	05/10/2019
08	Jakhama village (Nagaland)	25°35'2.91"N 94° 7'57.77"E	1573	26/09/2019
15	Kalpi-6. (Perennial) REC Fatehpur (Uttar Pradesh)	25°55'11.12"N 80°47'56.97"E	120	18/01/2020
20	Kumbi, (Manipur)	24°25'53.86"N 93°48'33.37"E	165	17/11/2020
21	YTP-1 (Perennial), TCRS, Tamil Nadu Agriculture University, Salem	11°39'7.37"N 78°28'8.94"E	285	13/03/2020
22	RSRS Campus, Imphal (Manipur)	24°50'18.14"N 93°56'35.78"E	782	17/11/2020

Table 2: Frequency of morphological traits in 12 perennial castor accessions

S.No	Characters	Frequency Distribution
1	Habit	Erect (75%), Semi erect (17%), Bushy (8%)
2	Growth Nature	Erect (75%), Spreading (25%),
3	Stem colour	Green (17%), Red (33%), Mahogany (25%), Pinkish red (8%) Reddish brown (17%
4	Lobe shape	Incised (100%)
5	Branching Nature	Divergent (42%), Convergent (58%)
6	Bloom	Non-bloom (83%), Triple-bloom (17%)
7	Leaf Shape	Peltate (100%)
8	Leaf colour	Light green (8%), Medium green (34%), Dark green (58%)
9	Leaf apex	Mucronate (59%), Acuminate (41%)
10	Leaf glossiness	Slightly glossy (42%), Non glossy (50%) Strongly glossy (8%)
11	Leaf Margin	Serrate (100%)
12	Leaf Surface	Smooth (42%), Slightly rough (50%), Rough (8%)
13	Flowering time	Precocious (25%), Medium (67%), Late (8%)
14	Mature shoot colour	Red (83%), Green (17%)
15	Anthocyanin pigmentation	Present (33%), Absent (67%)
16	Pigmentation of primary veins	Greenish (67%), Reddish (33%)
17	Wax on adaxial blade surface	Absent(83%), Present (17%)
18	Coloration of adaxial blade surface	Medium green (34%), Dark green (58%), Light green (8%)
19	Staminate flowers on the Raceme	Present (100%)
20	Location of staminate flowers	Predominantly on the lower part of the Raceme (92%), Interspersed with the pistillate flowers (8%)
21	Stigma coloration	Yellowish (8%), Reddish (92%)
22	Density of Raceme	Intermediate (83%), Sparse (17%)
23	Raceme shape	Conical (50%), Cylindrical (50%)
24	Fruit wax	Absent (83%), Present (17%)
25	Fruit coloration	Dark green (34%), Medium green (58%), Light green (8%)
26	Fruit Dehiscence	Non dehiscent (92%), Semi dehiscent (8%)
27	Presence of secondary coloration on seed	Present (100%)
28	Presence of Prickles on the fruits	Present (100%)
29	Density of the Prickles on the fruits	High (33%), Medium (67%)
30	Coloration of the fruit prickles	Medium green (84%), Pinkish green (8%), Dark green (8%)
31	Sex Expression	Monoecious (100%)
32	Phyllotaxy	Distichous (25%), Pentastichous (17%), Tristichous (58%)

33	Leaf texture	Membranous (42%), Coriacious (50%), Chartaceous (8%)

Table 3: Variability in metric traits of 12 perennial castor accessions

S. No.	Character	Observations	Min.	Max.	Mean	Variance	S.E	CV%
1.	Plant height (m)	108	0.87	2.56	1.53	0.19	0.04	28.90
2.	Inter-nodal distance (cm)	108	9.09	20	12.47	7.87	0.23	22.51
3.	Leaf area (sq.cm)	108	428.61	762.40	625.10	5732.56	6.12	12.11
4.	Lobe length (cm)	108	15	36	23.15	20.09	0.36	19.36
5.	Lobe breadth (cm)	108	8	22	14.08	12.10	0.28	24.70
6.	Petiole diameter(mm)	108	5.91	23.61	14.59	27.66	0.43	36.05
7.	Insertion of primary raceme(m)	108	0.66	1.57	1.02	0.05	0.02	21.88
8.	Stem diameter(mm)	108	15.56	47.52	29.57	51.56	0.58	24.28
9.	Length of primary raceme(cm)	108	18	42	29.26	18.74	0.35	14.79
10.	No. of shoot per plant(No)	108	4	15	8.81	6.42	0.20	28.70
11.	Total shoot length(m)	108	2.61	13.64	7.06	8.29	0.23	40.70
12.	100 leaf weight(g)	108	1409.20	2951.60	1891.20	6716.62	20.95	13.70
13.	No. of lobe(No)	108	7	11	9.56	0.94	0.08	10.15
14.	Seed yield(g)	108	18.37	57.94	32.31	57.27	0.61	23.42
15.	Leaf yield	108	0.73	1.92	1.12	0.06	0.02	21.17
16.	Leaf petiole ratio	108	1.05	3.21	1.82	0.29	0.04	29.75
17.	Leaf shoot ratio	108	0.42	2.20	0.80	0.06	0.02	29.28

Table 4: Variability in biochemical traits of 12 perennial castor accessions

S. No.	Character	Observations	Min	Max	Average	Variance	S.D	S.E	CV%
1	pH	36	5.01	5.89	5.60	0.03	0.17	0.03	3.01
2	Chl a	36	0.88	1.59	1.39	0.03	0.18	0.03	13.23
3	Chl b	36	0.29	1.83	0.88	0.15	0.38	0.06	43.52
4	Total Chl	36	1.43	3.32	2.27	0.18	0.43	0.06	18.80
5	Carotenoid	36	0.50	1.06	0.70	0.02	0.13	0.02	18.20
6	Total Chl/ Carotenoid	36	2.20	4.76	3.29	0.39	0.62	0.09	18.89
7	Protein	36	5.08	12.35	9.11	3.16	1.78	0.27	19.52
8	Anthocyanin	36	3.03	13.90	7.85	13.12	3.62	0.54	46.15
9	Carbohydrate	36	18.96	45.84	33.69	48.32	6.95	1.04	20.63
10	Total Sugar	36	0.66	1.62	1.03	0.05	0.23	0.03	22.71
11	Phenol	36	0.48	2.27	1.34	0.12	0.34	0.05	25.26
12	Amino acid	36	0.82	0.97	0.87	0.00	0.04	0.01	4.39
13	LMC%	36	73.81	84.36	77.25	3.98	1.99	0.30	2.58
14	MRC%	36	69.67	92.76	85.42	42.52	6.52	0.97	7.63

Table 5: Variability in bio assay traits of 12 perennial castor accessions

(Eri silkworm: Borduar)

S. No.	Character	No of Observations	Min.	Max.	Mean	Variance	S.E	CV%
1	Cocoon weight (gm)	120	2.03	5.74	3.84	0.49	0.05	18.17
2	Shell weight (gm)	120	0.25	0.56	0.42	0.00	0.00	13.48
3	Shell ratio	120	7.84	15.50	11.00	2.61	0.12	14.69
4	Pupa weight (gm)	120	1.74	5.29	3.43	0.44	0.05	19.24
5	Mature Larval Weight (gm)	120	6.22	9.82	7.98	0.67	0.06	10.28
6	Fecundity	36	290	410	353.67	1575.09	5.56	11.22
7	Hatching %	36	55	85	69.50	82.83	1.27	13.09
8	Larval duration	36	20	25	21.56	1.51	0.17	5.70
9	ERR	36	62.10	82.00	73.33	40.98	0.90	8.73

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