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SELECTION OF CASTOR (*RICINUS COMMUNIS*) CULTIVAR SUITABLE FOR COMMERCIAL ERI CHAWKI REARING

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ABSTRACT

The present study was conducted to screen the suitable castor (*Ricinus communis*) cultivar for use in commercial chawki (young age silkworms) rearing of eri silkworm (*Samia ricini* D.). Five commercially available cultivars of castor viz., NBR-1, Kalpi-6, DCH-519, ICH-66 and DCS-9 were sown in the field and standard package of practices were followed to select the economically viable cultivar in terms of plant growth and yield parameters. The results revealed varying degrees of growth and yield parameters in all five cultivars in terms of plant height, number of leaves per plant and leaf yield at different days after sowing. Among all the cultivars, higher growth and yield parameters was recorded in two cultivars (NBR-1 and Kalpi-6). Further, these two cultivars (NBR-1 and Kalpi-6) were selected for analysis of biochemical constituents. Higher moisture retention capacity (82.65%), protein content (20.60%), carbohydrate content (17.12%) and other leaf quality parameters which are essential for eri young age silkworms (chawki) were recorded in NBR-1. Among the two castor cultivars fed to eri-silkworm, NBR-1 fed worms recorded higher larval weight and more uniformity compared to Kalpi-6 fed worms. The results indicate suitability of NBR-1 cultivar in terms of growth, yield, biochemical constituents and eri young age silkworm rearing. Therefore, NBR-1 is recommended for commercial eri chawki rearing in view of the higher leaf yield obtained at different intervals in a year and superior in improving the rearing performance of eri chawki. Based on these findings a standard package of practice to raise NBR-1 cultivar for chawki rearing has been developed.

Keywords: *Castor cultivars, Growth and yield parameters, Biochemical constituents, Commercial eri chawki rearing, standard package of practices.*

Introduction

Northeast India is rich in seri-biodiversity and a natural habitat for various commercially exploited sericigenic insects (eri, muga, tasar and oak tasar) and their host plants. The states of Assam, Nagaland and Meghalaya contribute more than 90 % of the country's eri raw silk production. Other states that practice in a small scale are Arunachal Pradesh, Manipur, Uttar Pradesh, Bihar, Orissa, West Bengal, Andhra Pradesh, Tamil Nadu and Gujarat. Ericulture forms a unique component of agriculture in Northeastern India, where agro-forestry based farming is predominant and rapidly expanding sector in the vanya silk map of India (Mahesh and Arunkumar, 2020). Eri silk is next only to the mulberry silk in the silk production in India with a total production of 7364 MT in 2021-22 (Source:csb.gov.in). The Eri silkworm, *Samia ricini* (Donovan) is reared indoor for the production of cocoons. Eri-silkworm is one of the most exploited, domesticated and commercialized non-mulberry silkworms (Kedir Shifa *et al.,* 2014). It has many generations per year and feeds on several host plant species (Phukon, 1983; Bhattacharya *et al.,* 2006; Das *et al.,* 2006; Singh and Das, 2006; Chakravorty and Neog, 2006; Bindroo *et al.,* 2007).Farmers who generally produced eri silkworm eggs with their own practices or procured silkworm eggs from government grainages and raised the worms in their dwelling houses resulting in poor hatching percentage, more missing larvae, less uniformity, more starvation and several other problems during young age silkworm rearing (chawki rearing). The greater survivability and robust growth of late-age silk worms is directly related to rearing practices at chawki stage (Mahesh *et al.,* 2022). Poor systematic plantation of the host plants and small-scale rearing or age old practices at the farmers' level and in tribal communities have become stumbling blocks in uplifting ericulture from cottage rearing to commercial or industrial production. Therefore, total eri silk production has not increased at expected levels. Therefore, technological intervention in the form of Eri Chawki rearing practices will help address these problems by minimizing the early age loss and also in increasing the cocoon production and productivity by providing the robust chawki worms for the late age rearing.

There are several factors that are mainly responsible for the successful rearing of eri silkworm, namely- selection of host plants, leaf quality, selection of eri silkworm breed for

rearing, young age silkworm rearing (chawki-up to 2nd moult) and late age rearing practices (From 3rd instar to 5th instar), climatic factors (temperature and humidity) during rearing, etc. Among these factors, the selection of suitable host plant for rearing plays a crucial role in successful crop.

Eri silkworm rearers in Northeast India and other parts of the country mainly grow castor for foliage purpose as castor leaves are used for feeding Eri silkworm. Castor leaves are juicier and more nutritious than other host plants being used for Eri silkworm rearing (Singh and Das, 2006). Also, best suited for eri chawki rearing as the delicious leaves are very soft and succulent and have a high moisture retention capacity. However, among the castor which is most suitable for young age rearing of eri is not yet known. Therefore, we evaluated the commercially available castor cultivars based on their field performance and leaf quality to select the best and economically feasible cultivar for commercial eri chawki rearing.

Material and Methods

The study was conducted at Germplasm Conservation Center (GCC), Chenijan, Central Muga Eri Research and Training Institute (CMER&TI), Assam, India during 2019-2021. The castor cultivars were collected based on their commercial availability from different regions (Table 1).

Table 1: Source of castor cultivars collection

Sl. No.	Castor cultivars (Treatments)	Source of collection
1.	NBR-1 (T_1)	CMER & TI, Jorhat, Assam
2.	Kalpi-6 (T_2)	REC, Fatehpur, Uttar Pradesh
3.	DCH-519 (T_3)	Indian Institute of Oilseeds Research, Hyderabad, Telangana
4.	DCS-9 (T_4)	Indian Institute of Oilseeds Research, Hyderabad, Telangana
5.	ICH-66 (T_5)	Indian Institute of Oilseeds Research, Hyderabad, Telangana

The five cultivars were sown at GCC, Chenijan by following a standard package of practices for each variety. Four replications were maintained for each variety or treatment. 400 plants were maintained in each treatment and recorded the growth parameters *viz*., plant height and number of leaves at 30, 60 and 90 days after sowing(Table 1).After 90 days of sowing, only the top or tender leaves were collected and fresh weight was taken from the selected plants for each cultivar. Fresh leaf yield per plant was recorded in grams and converted the average leaf yield in kilograms to calculate the leaf yield per hectare. Based on the field performance and initial analysis NBR-1 and Kalpi-6 were selected for further experimentation and rearing. The quality parameters *viz*., moisture, moisture retention capacity, protein, carbohydrates, sugars, fibre, free amino acids, total chlorophyll, carotenoids, and ash of the selected cultivars were evaluated by following the standard protocols for analysis.

The rearing was conducted by using C2 breed of eri on both the selected cultivars and recorded the larval growth and larval uniformity by following the standard procedures as follows.

Assessment of growth of larvae: For every tray randomly collect 100 under moult larvae from different trays. Take the weight of larvae by using sensitive electronic balance.

Quantification of larval uniformity: Randomly collect 3-5 batches of 100 larvae each from different trays. Separate undersized larvae and count the number. Calculate % of undersized larvae using the following formula,

$$\% \text{ of undersized larvae} = \frac{\text{Number of undersized larvae}}{\text{Total number of larvae counted}} \text{ X } 100$$

Data analysis: The statistical design used is RCBD for field experiments.

Fig. 1 : NBR-1 (left) and Kalpi-6 (right) castor cultivars

Results and Discussion

Growth and yield parameters of castor

Among the tested castor breeds, significant differences were observed in the plant height and number of leaves per plant at 30, 60 and 90 days after seed sowing. Both NBR-1 and Kalpi-6 were found to be significantly higher in terms of plant height and number of leaves per plant compared to the other three cultivars. Higher plant height correlates to more leaves per plant and vice versa. Fresh leaf yield per plant was

highest in NBR-1 (105.35 g) followed by Kalpi-6 (87.45 g) compared to other varieties after 90 days or during first harvesting (Table 3). NBR-1 and Kalpi-6 were selected for further experimentation based on the quantity of leaves required for commercial eri chawki rearing. Various factors affect the growth performance of the plants, namely climatic factors, soil, plant physiology, nutrient absorption from the soil, etc. Though different parameters were recorded in the four crops, similar trends were observed. Hence, selection of a high yielding castor cultivar is the need of the hour to boost the eri culture at field level. In order to evaluate suitable castor genotypes for eri silkworm rearing, several attempts have been made by different investigators (Sarkar, 1988, Sannappa *et al.,* 2002, Chakravorty and Neog, 2006, Sarmah *et al.,* 2011). Based on leaf biomass yield of 41 accessions, a local non-bloomy red (NBR) castor variety was selected as the most promising variety with leaf yield of 12 MT/ha/year (Sarmah *et al.,* 2002). Further, varied growth performance in the present study is in conformity with the findings of Sarmah *et al.* (2011) and Sarmah (2013) where two genotypes of castor were selected as suitable in terms of leaf biomass yield.

Table 3: Plant growth parameters of different castor varieties at 30, 60 and 90 days after sowing

Castor varieties	30 DAS		60 DAS		90 DAS		Chawki leaves (gm/plant) after 90 days
	Plant height (CM)	No. of leaves / plant	Plant height (CM)	No. of leaves / plant	Plant height (CM)	No. of leaves/ plant	
NBR-1	31.25	8.3	82.95	20.75	129.15	43.2	105.35
Kalpi-6	34.55	7.15	83.60	18.65	132.25	41.1	87.45
DCH-519	30.00	6.85	78.20	17.25	101.25	31.65	71.99
DCS-9	29.95	6.15	73.45	15.65	97.95	27.3	65.93
ICH-66	28.65	6.40	72.65	16.75	99.40	28.55	62.25
CD	1.45	0.74	4.04	2.23	3.74	1.92	5.62
CV	0.61	1.37	0.67	1.63	0.43	0.73	0.93
SE.m	0.47*	0.24*	1.31*	0.73*	1.21*	0.62*	1.82*

Biochemical parameters of tender castor leaves:

NBR-1 is not only suitable owing to growth and yield parameters, but also in some of the key biochemical compositions of leaves, namely moisture content, moisture retention capacity, total chlorophyll, protein, free amino acids, carbohydrates, sugars, phenols and ash contents compared to Kalpi-6 (Table 4). The development of the Eri silkworm is strongly influenced by the biochemical composition of the castor leaves (Deuri *et al.,* 2017). Moisture retention capacity is one of the important biochemical compositions of the castor leaves since the eri chawki worms prefer leaves with high moisture content. Also, protein and carbohydrates content of the leaves are considered as key biochemical components for eri chawki rearing. The results revealed that NBR-1 has a better biochemical composition than Kalpi-6. The quality parameters of castor leaves were assessed by various investigators (Gururaj *et al.* (2016), Sarmah *et al.* (2011) and Deuri *et al.,* 2017) and recorded the higher number of nutritional values.

Table 4: Biochemical composition of castor leaves

Parameters	NBR-1	Kalpi-6	DCH-519	DCS-9	ICH-66
Moisture (%)	80.31±0.42	79.18±0.39	70.69±0.27	73.68±0.29	75.19±0.33
Moisture retention capacity (%)	82.65±0.37	71.83±0.62	66.32±0.34	70.56±0.24	71.92±0.31
Protein (%)	20.60±0.25	16.30±0.18	14.08±0.15	15.79±0.20	14.93±0.16
Total carbohydrates (%)	17.12±0.52	15.39±0.56	14.59±0.21	13.11±0.18	14.08±0.20
Total sugars (%)	8.62±0.30	8.12±0.25	6.44±0.16	5.85±0.20	7.51±0.25
Reducing Sugars (%)	1.23±0.05	1.09±0.02	0.93±0.11	1.03±0.07	1.06±0.04
Fiber content (%)	6.49±0.38	7.03±0.41	6.15±0.35	5.98±0.42	6.91±0.32
Free amino acids (%)	0.75±0.04	0.52±0.03	0.39±0.02	0.41±0.04	0.45±0.06
Total chlorophyll (mg/g)	2.85±0.16	1.78±0.08	1.55±0.10	1.46±0.17	1.64±0.12
Carotenoids (mg/g)	0.098±0.02	0.059±0.01	0.049±0.01	0.054±0.02	0.055±0.01
Ash (%)	5.89±0.40	5.21±0.26	4.31±0.22	4.12±0.31	5.08±0.23

Rearing performance of eri chawki worms reared on NBR-1 and Kalpi-6 varieties:

As per the chawki certification norms, the higher 100 larval weight (5.86±0.14 g) before 2nd moult and more larval uniformity (98.8±0.84 %) was recorded in the NBR-1 fed batch compared to Kalpi-6 where less 100 larval weight (5.13±0.17 g) before 2nd moult, and less larval uniformity (90.4±2.30 %) was recorded (Table 5). The relationship between quality parameters of castor leaves exhibited positive correlation with all economic traits of eri silkworms. The difference in the rearing performances of eri-silkworms could be attributed to the differences in the nutritional composition; such as moisture, proteins, carbohydrates, minerals, fat, vitamins, etc., of the leaves of the different castor genotypes. Similar studies conducted by Patil *et al.*

(2009), Jayaramaiah and Sannappa (1998) and Sengupta *et al*. (2008). Therefore, selected NBR-1 as a superior castor cultivar for eri chawki rearing for further development of standard packages.

Table 5: Rearing performance of eri chawki worms reared on NBR-1 and Kalpi-6

Castor cultivars	100 Larval weight (g) before 2nd moult	Larval uniformity (%)
NBR-1	5.86±0.14	98.8±0.84
Kalpi-6	5.13±0.17	90.4±2.30

Standard package of practices Eri Chawki Garden

The standard package of practices was developed by selecting NBR-1 as a suitable cultivar for eri chawki worms. The Castor Chawki Garden was planned based on the DFLs to be brushed in a year in 6 plot module system (Table 9). Following are the requirements for a castor chawki garden per hectare and the yield per hectare to raise chawki worms in a year.

Land selection: The land should be devoid of any water logging. Fertile sandy loamy soil or alluvial soil is preferable. Soil testing is a prerequisite for knowing the physical and chemical properties of the soil. It also helps in re-modifying fertilizer dose based on soil test results.

Suitable sowing time: 1st week of March to 4th week of April or 1st week of August to 4th week of September are ideal seasons for sowing castor seeds.

Seed treatment: Soak castor seeds in water for 24 hours and treat with Carbendazim 50% WP @ 3g/kg for 10-15 minutes before sowing to avoid fungal infections.

Suitable castor variety, seed requirement, spacing and sowing procedure: NBR-1 (Non-Bloomy Red strain) is the best-suited cultivar for Eri-Chawki worms and is also a popular cultivar in the cultivation system that is plentiful in the Northeast region. Six kilograms of seeds are needed to create one hectare of castor chawki plantation. Two to three seeds should be sown at a depth of 2.5 to 3.0 cm per hill to maintain plant population per hectare. Castor should be sown with a spacing of 1 x 1 meter (1 meter from plant to plant and 1 meter from row to row) in a raised bed (approx. 15 cm) to avoid water logging around the castor plants on rainy days. Apply about 0.5kg of FYM (Farm Yard Manure) per pit during sowing and FYM should be mixed with soil. Sow at least three seeds per pit. After sowing castor seed, the irrigation should be provided daily, depending on the soil conditions, until the seeds germinate. After germination allow the plant to grow for week up to 10 cm and then only one healthy plant per pit should be retained and other plants should be removed. A total of ten thousand plants per hectare of cultivation area should be cared for to get better yield, to get the right light and even aeration for all plants. Maintaining the correct plant population aids in easier fertilizer management without disturbing the root zone.

Harvesting of leaves: Since the NBR-1 is annual in nature a total of six harvests can be made per year. The first harvest should be made after ninety days of sowing. Subsequent harvest must be after sixty days of each harvest (Table 6).

Table 6: NBR-1 castor leaf harvesting schedule

Number of harvests	Time of harvesting
1st harvest	90 days after sowing
2nd harvest	60 days after 1st harvesting
3rd harvest	60 days after 2nd harvesting
4th harvest	60 days after 3rd harvesting
5th harvest	60 days after 4th harvesting
6th harvest	60 days after 5th harvesting

Irrigation frequency: After germination, at least two watering per week should be provided to maintain soil moisture.

Fertilizer requirement and application schedule for castor: 30 MT of FYM and 270:120:60 kg of chemical fertilizers ($(N_2:P_2O_5:K_2O)$ are required for castor chawki garden per hectare per year. For chawki nursery garden, FYM should be applied during the sowing and after 1 month of sowing in equal proportions (0.5 kg per plant). Then 1 kg of FYM per plant should be applied in the 5th and 9th month after sowing. Urea should be applied at intervals of 60 days starting from the 1st to 11th month after sowing since castor requires more nitrogen after each harvest to obtain good amount of foliage (Table 7). Fertilizers (NPK) as per the package should be applied immediately after each harvest to get good leaf yield. Only tender leaves should be used for chawki and older leaves can be utilized for late age rearing without affecting plant development.

Table 7: Schedule of application of FYM and chemical fertilizersto castor chawki garden

Time of application	FYM (Kg / pit)	Nitrogen (Urea) g/plant	Phosphorous (SSP) g/plant	Potash (MOP) g/plant
During sowing	0.50	-	-	-
30 days after sowing	0.50	13.0	25.0	3.00
90 days after sowing (or first harvesting)	-	7.00	-	-
60 days after 1st harvesting (150 DAS)	1.00	13.0	25.0	3.00
60 days after 2nd harvesting (210 DAS)	-	7.00	-	-
60 days after 3rd harvesting (270 DAS)	1.00	13.0	25.0	3.00
60 days after 4th harvesting (330 DAS)	-	7.00	-	-

Harvesting of leaves: Harvest the castor leaves based on tenderness after 90 days (2nd, 3rd leaves from top for 1st instar and 4th, 5th and 6th leaves for 2nd instar larvae). Continue harvesting up to 390 days at the interval of 60 days. First harvest of castor leaves should be carried out only after 90 days of sowing to allow good growth of stem of the plant which further helps in obtaining good foliage for subsequent crops (Table 8). After 390 days of sowing, a new plantation should be planned since the yield of the plant reduces. NBR-1 castor plantation can be taken up every year since it is an annual variety and gives more yield within short duration when compared to other varieties.

Table 8: The yield of Chawki leaves at different intervals in a year and number of DFLs that can be reared/ hectare of NBR-1 castor leaves

Harvesting time	Castor chawki leaves yield (Kg/ha)	Number of DFLs reared /ha
1st harvesting (90 days after sowing)	1125	15000
2nd harvesting (60 days after 1st harvesting)	1350	18000
3rd harvesting (60 days after 2nd harvesting)	1575	21000
4th harvesting (60 days after 3rd harvesting)	1125	15000
5th harvesting: (60 days after 4th harvesting)	900	12000
6th harvesting: (60 days after 5th harvesting)	675	9000
Total	6750	90000

A total of 90,000 DFLs can be brushed per hectare of castor plantation per year. The brushing capacity of DFLs can be scheduled based on the amount of leaves available to harvest from the castor plot. Leaf yield varies from crop to crop because as an annual castor cannot be pruned to get more foliage. About 6750 kg of chawki leaves can be harvested per hectare of land. DFLs can be brushed in six batches per hectare by staggered seeding as suggested in Table 8. Additional sowing can be taken up during March to April or August to September season based on the demand of chawki worms.

The advantage of staggered sowing of castor seeds is to reduce the need for a large number of working days at once for the preparation of the entire plot and other operations. Staggered sowing can be accomplished with the labor available in the family. It also makes it easy to plan for frequent brushing of chawki worms in a month (3 batches) as shown in the Table 9.

Table 9: Plan for sowing of castor seeds and brushing/ hectare of eri chawki worms (6 plot module of 1667 plants/plot).

Sowing time (6 plot module) in 1 hectare		Brushing months					
	Batches	**June**	**August**	**October**	**December**	**February**	**April**
March 1st	1st batch	2500 DFLs	3000 DFLs	3500 DFLs	2500 DFLs	2000 DFLs	1500 DFLs
March 11th	2nd batch	2500 DFLs	3000 DFLs	3500 DFLs	2500 DFLs	2000 DFLs	1500 DFLs
March 21st	3rd batch	2500 DFLs	3000 DFLs	3500 DFLs	2500 DFLs	2000 DFLs	1500 DFLs
Total		7500	9000	10500	7500	6000	4500
		Brushing months					
	Batches	**July**	**September**	**November**	**January**	**March**	**May**
April 1st	1st batch	2500 DFLs	3000 DFLs	3500 DFLs	2500 DFLs	2000 DFLs	1500 DFLs
April 11th	2nd batch	2500 DFLs	3000 DFLs	3500 DFLs	2500 DFLs	2000 DFLs	1500 DFLs
April 21st	3rd batch	2500 DFLs	3000 DFLs	3500 DFLs	2500 DFLs	2000 DFLs	1500 DFLs
Total		7500	9000	10500	7500	6000	4500

Conclusion

The present study revealed that suitable castor cultivar has strong influence on commercial eri chawki rearing. Hence, selection of suitable castor cultivar for commercial eri chawki rearing based up on the growth, yield, leaf quality and chawki rearing performance of eri silkworms is very important in order to obtain robust larval batch for late age eri rearing to increase productivity in cocoon yield and crop success rate. NBR-1 castor cultivar emerged as promising commercially suitable cultivar since it has recorded the superior growth, yield and biochemical parameters and in turn to rear the young or early age eri worms (eri chawki). The developed package on NBR-1 chawki garden module and its economics helps new entrepreneurs or lead farmers for systematic planning of commercial eri chawki rearing to get more income. Therefore, NBR-1 variety of castor is recommended for commercial eri chawki rearing in ericulture with respect to Northeast India. This study also helps the new ericulture areas for easier penetration of the new technologies. However, research should be continued in new ericulture areas or non-traditional areas like Uttar Pradesh, Gujarat, Tamil Nadu etc. for the selection of region specific variety with leaf defoliation studies to integrate eri silkworm rearing with castor oil seed production in the future.

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