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Rearing Performance of Eri-Silkworm (*Samia cynthia ricini* Boisduval) (Lepidoptera: Saturniidae) Fed with Different Castor (*Ricinus communis* L.) Genotypes

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ABSTRACT

Growth, development, reproduction and yield of silkworms depend on the availability and supply of preferred host plants having good agronomic and nutritional characteristics. Eri-silkworm, *Samia cynthia ricini* B. is a multivoltine and polyphagous insect feeding on diversified host plants among which castor is a primary host plant. There is differential preference for the different varieties of castor by *S.c. ricini*. In the present study, eight different castor genotypes; namely Abaro, Acc 106584, Acc 203241, Acc 208624, Ar sel, Bako, GK sel and local were evaluated for their merits as feed and nutritional sources for white plain *S.c. ricini* at Melkassa Agricultural Research Center, Ethiopia. The treatments were arranged in a Completely Randomized Design (CRD) in three replications. Fifty worms were used in each replication. Significant difference was observed in rearing performance of eri-silkworms when fed to leaves of different castor genotypes. Among castor genotypes fed to eri-silkworm, Abaro fed worms showed medium to maximum records of matured larval weight (8.17 g), effective rate of rearing (74.68%), survival rate (76.08%), cocoon weight (3.34 g), pupal weight (2.86 g), shell weight (0.48 g), silk ratio (14.49%), fecundity (382.00), hatchability (88.17%) and shorter larval duration (584.17 h). In conclusion, genotype Abaro was superior to the other genotypes in improving the rearing performance of eri-silkworms and can be recommended for further research and development work in integrating silkworm activities for silk and oil seed productions.

Key words: Castor genotypes, eri-silkworm, *Samia cynthia ricini*, rearing performance

INTRODUCTION

Silk is a functional term used to describe natural-protein fibers that are secreted by arthropods (Chowdhary, 2006). Silk production has the potential to make a significant contribution to the economy of many countries where there is surplus labor, low-costs of production and a willingness to adopt new technologies (Hajare *et al.*, 2007).

Silk has strong affinity to the people of Ethiopia starting from ancient period of Axum Kingdom. However, the silk yarns used were imported from India, Arabia and China though the country has diversified climate and vegetation to support diversified options of silk industry (Spring and Hudson, 2002). Belli (1947) reported that there were no known records of silk being produced in

the country until 1930's. Currently, Ethiopia is the second populous country in Africa after Nigeria. There is a general trend of increasing unemployment. Therefore, sericulture, an agro based labour intensive and environment friendly cottage industry, can become an efficient and effective agricultural endeavor for the country. The business holds a ray of hope at village level for Ethiopian citizen migrating to cities searching jobs. Though, several research and development efforts were attempted on silkworms, in Ethiopia in the past decade including eri silkworms, none of them resulted in large scale production of silk like Asian and some African countries. As a result, silk production from eri silkworm is practiced bits in bits in different parts of the country especially by poor farmers as an additional income source through efficient use of family labor (Metaferia *et al.*, 2007).

Eri-silkworm, *S.c. ricini*, is one of the most exploited, domesticated and commercialized non mulberry silkworms. 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). It is a domesticated silkworm and can be reared in doors (Joshi, 1992). It feeds on over 29 species of host plants (Reddy *et al.*, 2002). Among all host plants, castor (*Ricinus communis* L.) is the most preferred host plant for eri-silkworm (Naika *et al.*, 2003; Sannappa *et al.*, 2004; Kumar and Elangovan, 2010). However, *Manihot utilissima*, *Heteropanax fragrance*, *Curica papaya*, *Evodia falcinifolia*, *Sapium eugenifolia*, *Jatropha curcas*, *Gomelina arborea*, etc., are secondary and tertiary hosts (Phukon, 1983). In separate experiments, the superiority of castor among the different host plants have been mentioned by other authors (Dayashankar, 1982; Devaiah *et al.*, 1985; Sakthivel, 2004). Moreover, about 25-40% of castor foliage can be defoliated (removed) and used for feeding eri-silkworm without affecting oil seed production (Raghavaiah, 2003; Jayaraj, 2004).

Castor grows widely and abundantly in many parts of Ethiopia. In addition to cultivated castor on cultivable lands, it is also found wild in waste places, fallow fields, along road sides and irrigation canals among others (Metaferia *et al.*, 2007). It is dominantly used for oil seed production; however, it is also used for rearing of eri-silkworms especially in the rift valley areas and southern region of Ethiopia.

Eri silkworm larvae feed on castor leaves to obtain essential nutrients for their growth, survival, production of silk cocoon and reproduction. Thus, successful eri silk production depends on nutritive value of castor leaves. Krishnaswami *et al.* (1970) reported that the growth and development of eri-silkworm larvae, reproductive capacity of adults and the quality of silk produced are highly dependent on the quality of castor leaves fed to the worms. Growth, development and economic traits of silkworms are influenced by the host plants and their nutritive contents (Singh and Das, 2006). However, castor shows a wide range of diversity in nature. It has been well recognized that morphological features and nutritive values of the leaves differ significantly from variety to variety and over locations. Patil *et al.* (1998) has reported significant variation in performance of eri-silkworms when different castor genotypes were fed to the different instars of the larvae. An extensive study has been made in India on larval growth and rearing performances of eri-silkworm as influenced by host plants.

Hence, it can be recognized that selection of castor genotypes is an important criterion for better growth and development of eri-silkworm larvae to obtain better fecundity, silkworm development and cocoon productivity. However, the differential performance of eri-silkworm on different castor genotypes has not been researched and documented in Ethiopia. Therefore, this work was carried out to know the influence of castor genotypes on rearing performance of eri-silkworms to identify promising castor genotype for integrated production of silk and seed oil.

MATERIALS AND METHODS

Description of the study site: The study was conducted at Melkassa Agricultural Research Center (MARC), which is one of the Research Centers under the Ethiopian Institute of Agricultural Research (EIAR). It is found 117 km away from Addis Ababa and 17 km to southeast of Nazareth in the East-Shewa zone of Oromia regional state in Ethiopia. It is located 8°24'N latitude and 39°12'E longitude having an elevation of 1550 m above sea level and a mean annual rainfall of 770 mm.

Experimental procedures: White plain eri-silkworm breed was used for the experiment. It was reared on eight castor genotypes, which were procured from oilseeds research division of MARC and Institute of Biodiversity Conservation. The castor genotypes were planted and managed similarly as per the recommended package of practices for the crop in the area. The experiment was designed in a Completely Randomized Design (CRD) and the treatments were replicated thrice. In each replication, 50 worms were used and allowed to complete the larval period on the selected genotype of castor. The silkworm rearing room and equipments were cleaned, washed and disinfected with 2% formalin solution at the rate of 800 mL 10 m⁻² before the commencement of the experiment (Dayashankar, 1982). This breed was reared following cellular rearing techniques starting from brushing till cocoon spinning on the eight genotypes. Tender leaves of castor were fed four times a day until the larvae ends 2nd instar stage and semi tender leaves to 3rd instar, while more matured leaves were fed to 4th and 5th instar larvae.

Matured worms were picked and mounted on the mountages for spinning. On the sixth day of spinning, the cocoons were harvested, counted and weighed (Singh and Benchamin, 2002).

Data collected: Rearing variables like larval duration (h), mature larva body weight (g), larval survival (%), hatchability (%) and effective rate of rearing (%) were the data recorded. Moreover, cocoon traits (single cocoon, pupal and shell weight in grams and silk ratio in percent) and fecundity (eggs per female in number) were recorded.

Formulae adopted from Singh and Benchamin (2002) were used for data analysis on rearing performance as follows:

$$\text{Survival rate} = \frac{\text{No. of survived larvae}}{\text{No. of larvae brushed}} \times 100$$

$$\text{Hatchability (\%)} = \frac{\text{No. of normal eggs} - \text{No. of non-hatched eggs}}{\text{No. of normal eggs}}$$

$$\text{Effective rate of rearing} = \frac{\text{No. of larvae spinning cocoon}}{\text{No. of larvae brushed}} \times 100$$

Data analysis: Collected data were analyzed using SAS software at 5% level of significance (SAS, 2000). Significant means (p<0.05) were separated using Least Significant Difference (LSD).

RESULTS

The result of the experiment, i.e., rearing performances of eri-silkworms in relation with egg, larval and cocoon traits as influenced by different castor genotypes were presented hereunder.

Fecundity: Silkworm fed on Acc 106584 showed significantly higher fecundity (409 eggs/female) followed by GK sel (389 eggs/female) and Abaro (382 eggs/female). The local check, which was at par with Ar sel and Acc 203241, was lower performing compared to the rest of the castor genotypes for fecundity (Fig. 1).

Hatchability: Similarly, hatching percentage showed significant variation when larvae of eri-silkworm were fed on different castor genotypes. Hatching percentage ranged from minimum of 81.50% for Acc 203241 to maximum of 95.33% for Acc 106584. The next best genotype in improving the hatching percentage of moths was genotype GK sel (93.83%) followed by Abaro (88.17%). The local genotype showed better hatching percentage than Acc 203241 and Ar sel only (Table 1).

Larval duration: Eri-silkworm larval duration has also showed significant variation when silkworms were supplied with different castor genotypes. Significantly longer larval durations (604.17 h) were recorded from the worms fed on Bako. However, there was no significant difference among other castor genotypes which showed a range of 588.17-592.17 h larval duration.

Survival rate: The survival rate of silkworm larvae on different castor genotypes showed significant variation. The highest survival rate was recorded from silkworms reared on Acc 208624 (78.349%) followed by GK sel (77.748%), Bako (77.656%), Acc 108584 (76.494%) and Abaro (76.079%). The least survival rate was recorded from the local check (66.117%) (Table 1).

Table 1: Effect of castor genotypes on eri-silkworm egg hatchability, larval duration, larval survival rate and effective rate of rearing

Castor genotypes	Hatchability (%)	Larval duration (h)	Survival rate (%)	Effective rate of rearing (%)
Abaro	88.1667 ^b	584.17 ^b	76.079 ^{ba}	74.68 ^a
Acc106584	95.3333 ^a	584.17 ^b	76.494 ^{ba}	69.32 ^c
Acc203241	81.5000 ^d	588.17 ^b	73.864 ^b	73.38 ^a
Acc208624	87.0000 ^b	588.17 ^b	78.349 ^a	73.18 ^a
Ar sel	82.1667 ^d	588.17 ^b	70.868 ^c	70.32 ^{ba}
Bako	86.5000 ^{cb}	604.17 ^a	77.656 ^a	73.15 ^a
GK sel	93.8333 ^a	592.17 ^b	77.748 ^a	69.92 ^{bc}
Local	84.8333 ^c	588.17 ^b	66.117 ^d	65.36 ^d
SE	0.6095308	3.7454	0.9520753	1.1751
CV (%)	1.207708	1.10001	2.209129	2.4547
Pr	<0.0001	0.0363	<0.0001	<0.0001

*Means followed by the same letter within a column are not significantly different from each other at 5% level of significance

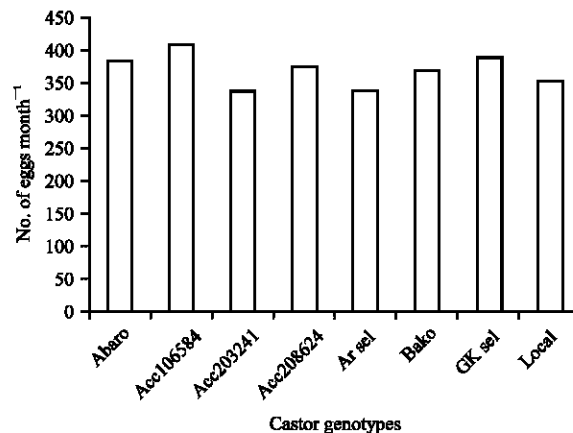


Fig. 1: Effect of castor genotypes on fecundity of eri-silkworm moths

ERR (%): Effective Rate of Rearing (ERR), which reveals percentage of the number of cocoons harvested to number of larvae brushed, has also showed a significant difference when eri silkworms were fed on different castor genotypes. Eri silkworm fed on Abaro registered maximum ERR (74.68%) closely followed by Acc 203241 (73.38%), Acc 208624 (73.18%) and Bako (73.15%). The least ERR was obtained from local check (65.36%) (Table 1).

Matured larval weight: Weight of a single matured silkworm larva was significantly different among the treatments. Matured worms fed on Bako and Abaro recorded significantly higher larval weight, 8.20 and 8.17 g, respectively. However, the least larval weight was obtained from worms fed on local check (7.60 g) (Fig. 2).

Cocoon traits: With respect to cocoon traits, maximum and significantly different single cocoon weight was recorded from those larvae which were fed with the leaves of Abaro (3.344 g) followed by Acc 208624 (3.307 g). Minimum single cocoon weight (3.131 g) was recorded from larvae fed on Acc 203241 but this genotype was statistically on par with local (3.144 g) and Acc 106584 (3.149 g) genotypes in single cocoon weight performance. Similarly, the highest and significant single pupa weight was obtained from worms fed on Abaro (2.860 g) and the lowest was obtained from those fed on Acc 203241 (2.684 g) (Table 2).

In addition, single cocoon shell weight showed significant variation when worms were fed with the different castor genotypes. Abaro yielded maximum and significantly higher shell weight

Table 2: Effects of castor genotypes on cocoon, pupal and shell weight and cocoon shell ratio of eri-silkworms

Castor genotypes	Cocoon weight (g)	Pupal weight (g)	Shell weight (g)	Silk or shell ratio (%)
Abaro	3.3440 ^{ab}	2.860 ^a	0.4840 ^a	14.4870 ^a
Acc106584	3.1490 ^b	2.695 ^b	0.4530 ^b	14.3950 ^b
Acc203241	3.1310 ^b	2.680 ^b	0.4470 ^b	14.2810 ^d
Acc208624	3.3070 ^b	2.830 ^b	0.4770 ^b	14.4240 ^{bc}
Ar sel	3.2160 ^c	2.751 ^c	0.4650 ^c	14.4580 ^{ba}
Bako	3.1860 ^d	2.725 ^d	0.4610 ^{bc}	14.4710 ^{ba}
GK sel	3.2050 ^{bc}	2.747 ^{bc}	0.4580 ^d	14.3050 ^d
Local	3.1440 ^c	2.702 ^c	0.4430 ^c	14.0730 ^c
SE	0.0086	0.0074	0.0014	0.0177
CV (%)	0.4653	0.4664	0.5135	0.2131
Pr	<0.0001	<0.0001	<0.0001	<0.0001

*Means followed by the same letter within a column are not significantly different from each other at 5% level of significance

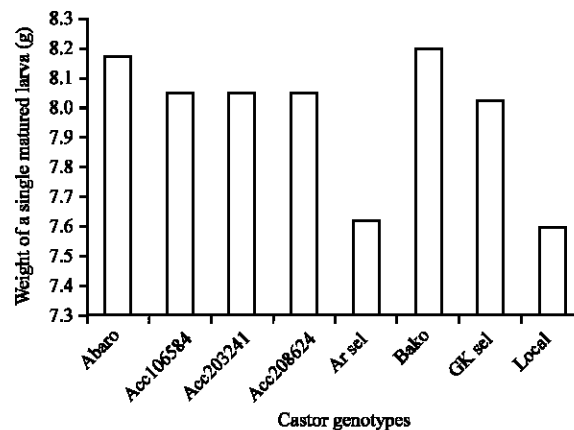


Fig. 2: Effect of castor genotypes on eri-silkworms single larval weight (g)

(0.484 g) but local check showed the least shell weight (0.443 g). Similar to single cocoon shell weight, silk ratio was found to be significantly higher in Abaro (14.487%) closely followed by Bako (14.471%) and Acc 203241 (14.458%), while the lowest was recorded from the local check (14.07%) (Table 2).

DISCUSSION

Rearing performance study on eri-silkworm as influenced by castor genotypes was carried out and differences in these genotypes were evaluated based on different response variables measured from the worms fed with the leaves of the genotypes. In general, the results indicated that castor genotypes viz., Abaro, Acc 106584, Acc 203241, Acc 208624, Ar sel, Bako, GK sel and local check resulted in significant variation in rearing performances of the worms. It is a well documented fact that insects do vary in efficiency of conversion of digested food due to the varied level of nutrients intake, quality of the food and total biochemical components of the leaf supplied to the insects (Sengupta *et al.*, 2008).

In general, among castor genotypes studied, silkworms fed on Abaro gave the highest cocoon weight, shell weight, pupal weight, silk ratio and ERR. With respect to hatching percentage, larval weight, fecundity and survival rate; the same genotype was the second or the third best. On the other hand, Acc 208624 fed worms showed the highest survival rate with above medium records for the rest of the variables measured. 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) in India found differences in larval, cocoon and post cocoon traits of eri-silkworms when fed with different castor genotypes. Besides, Sannappa *et al.* (2007) mentioned variation in larval, cocoon and grainage variables for eri-silkworms when fed on different castor genotypes in South India. They recommended Aruna castor variety for rearing of eri-worms for commercial traits. Eri silkworm's silk production depends on the amount of feed provided to the larvae, the rate at which the feed is provided and quantity of leaf consumed by the larvae. These in turn influence the growth rate, development time, body weight, survival percentage, intensity of silk secretion, adult emergence, mating success and extent of reproduction (Sannappa *et al.*, 2007).

In this particular study, genotype Bako fed worms resulted in the highest larval weight, but with longer larval duration and lower weights of cocoons, pupae and cocoon shell. Similar findings by Jayaramaiah and Sannappa (1998) confirmed castor genotypic differences on feeding efficiency of eri silkworms. Food consumption rate of eri-silkworm may depend on the phagostimulant nature of the leaf, existing physical factors, nature of leaf and moisture content of leaf of castor genotypes. El-Shaarawy *et al.* (1975) opined that bloomy red variety of castor is preferred from bloomy green variety by eri silkworm larvae. Many researchers on eri-silkworm vis-à-vis host plant relationship such as Sannappa *et al.* (2002) and Govindan *et al.* (2005) registered variations in total food consumption among different castor genotypes when offered as food to eri silkworm both on fresh and dry weight basis.

Furthermore, local genotype fed silkworm's recorded minimum values for most rearing performance indicators. It may be because its leaf contains less of important nutrients and/or has lower efficiency to be converted to larval, cocoon and post cocoon traits of eri silkworms. Or it may be due to the presence of some anti-nutritional components like high amount of fiber or some protein binding tannins in the leaf of local variety. Therefore, the present study revealed that

Abaro, which showed 3.344 and 0.484 g single cocoon weight and single shell weight, respectively, is the most promising castor genotype with respect to cocoon traits and other rearing variables. It is comparable with findings of Patil *et al.* (1998) who obtained single cocoon and shell weights of 3.817 and 0.4433 g, respectively in a selected castor genotype called RG-323 in India. Moreover, Abaro genotype was even better performing than 2.132 and 0.339 g of single cocoon and shell weights, respectively, obtained from the selected Aruna genotype by Sannappa and Jayaramaiah (1999).

CONCLUSION AND RECOMMENDATIONS

The present study revealed that castor genotypes have strong influence on eri silkworm rearing performance. Hence, selection of castor genotypes for rearing eri silkworm based up on rearing performance of eri silkworms is very important in order to get better egg production, larval development and cocoon yield. Therefore, castor genotype named Abaro was found to be the best promising with respect to rearing performance indicators of eri silkworm especially with regard to cocoon traits. Therefore, Abaro genotype of castor is recommended for eri silkworm research and development efforts in the future in Ethiopia.

However, more research should be carried out to support the current findings with regard to different pests and disease management options, agronomic practices and foliar composition studies. Leaf defoliation studies will also be required to be studied to integrate eri silkworm rearing with castor oil seed production in the future.

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