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Correlation Between Bio-Chemical Composition of Castor Leaf with Bio-Energetics and Economic Parameters of Selected Eco-Races of Eri Silkworm

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Abstract
An attempt has been made to work out the correlation co-efficients between bio-chemical composition of castor leaf (DCH-177 hybrid and Local Pink variety) with bio-energetics and economic parameters of selected eco-races (Borduar, Dhanubanga, Khanapara, Kokrajhar, Mendipathar and Titabar) of eri silkworm (*Samia cynthia ricini* Boisduval) and bio-energetics with economic parameters. The study established that, the bio-chemical composition of castor leaf *viz*., leaf moisture, total chlorophyll, total protein, sugars, nitrogen, phosphorous, potassium, calcium, magnesium and sulphur were found to have highly significant positive relationship with the bio-energetic indices *viz.,* food consumption, food digestion, consumption index, approximate digestibility, growth rate, efficiency of conversion of ingesta, efficiency of conversion of digesta, coefficient of metabolism, reference ratio and metabolic rate except with that of total protein and total sugars on food consumption, food digestion, ECD and reference ratio. Further, bio-chemical constituents of leaf found significant positive relation with economic characters *i.e.,* matured larval weight, cocoon yield, shell weight, shell yield, shell ratio, silk productivity, rate of pupation and fecundity, while it was significant negative correlation with cocoon weight and rate of pupation and non-significant negative correlation with pupal weight. On the other hand, bio-energetic parameters did show highly significant positive relationship with economic parameters of eri silkworm except for pupal weight, shell yield and fecundity which showed negative significant correlation. The study inferred that, biochemical composition of castor leaf and bio-energetic indices of eri silkworm did play a major role in determining the economic characters and hence efforts must be made to improve the quality of castor leaf and conversion efficiency of food in eri silkworm to improve the economic parameters.

Keywords
Bio-chemical composition, Bio-energetics, Castor Hybrid/Variety, Correlation, Economic parameters.

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INTRODUCTION

Silk plays an important role in the economic life of man ever since its discovery as early as 4500 years ago. Among the manmade fibers, silk continues to reign supreme as the "Queen of Textiles". Apart from the marvelous mulberry silk, there are a few other varieties that are equally attractive. They are Tasar, Eri and Muga silks collectively termed as '*Vanya Silks*'. Among them, eri silk is becoming more popular in recent years, because of its domestic and multivoltine nature.

The eri silkworm being a phytophagous insect, its growth, development and economic traits are mainly governed by the chemical composition of leaves that serve as food. Foliar constituents of castor had a positive correlation with economic parameters *viz*., cocoon weight, shell weight, shell ratio and fecundity, while larval duration, pupal duration and sericin content had negative significant relationship [1].

The selection of castor genotypes is an important factor for better growth and development of eri silkworm for higher productivity in terms of cocoon yield. It has also been observed that the silk ratio varies with the type of host and eri silkworm breed used for rearing [2]. The foliar constituent's *viz*., leaf moisture, total carbohydrates, total amino acids, phosphorus, potassium, calcium, magnesium and sulphur contents in castor genotypes showed positive significant relationship with larval, cocoon and grainage parameters, indicating that foliar constituents have a strong bearing on larval development, cocoon and egg production of eri silkworm. This offers a wide scope in selection of castor genotypes for rearing of eri worms both for commercial and seed cocoon production [3].

The growth, development and reproductive potentiality of insects mainly depends on nutritional composition of food, which includes both the absolute and relative amount of water, carbohydrates, proteins, amino acids, lipids, fatty acids, vitamins, minerals, *etc*. The amount, rate and quantity of leaf consumed by the insects influence the growth rate, development duration, body weight and survival percentage besides affect the adult emergence, mating success, extent of reproduction, *etc*. The process of consumption, digestion and conversion efficiency in insects in broader sense relates to the physiological, behavioral, ecological and evolutionary aspects of insect life [4].

The correlation between bio-chemical constituent's *viz.,* crude protein and total carbohydrates showed positive significant relationship with effective rate of rearing, cocoon yield, shell weight and shell yield, shell ratio and silk productivity; total carbohydrates with cocoon weight, fibroin and rate of pupation [5]. Literature pertaining to the current investigation is meager, hence attempt has been made to work out the correlation between bio-chemical composition of castor leaf with bio-energetics and economic parameters in selected eco-races of eri silkworm.

MATERIALS AND METHODS

Cultivation of castor

DCH-177 hybrid and Local Pink variety of castor were raised at a spacing of 90 x 60 cm in four replications by adopting Randomized Block Design by adopting recommended package of practices under irrigated condition [6].

Bio-chemical analysis of castor leaf

The castor leaf samples were collected from the established plot at different maturity levels *viz*., tender (from top 3rd to 5th leaf), medium (from 6th to 9th leaf) and coarse (from 10th leaf downwards) leaves to prepare composite samples and dried under shade for three days and later dried in hot air oven at 70°C until reaches constant weight. The dried leaf samples of castor hybrid / variety were powdered into fine particles and preserved in butter paper bags for chemical analysis and each sample comprise of four replications.

Moisture content in castor leaf samples was estimated by taking differences between fresh and dry weight and expressed in percentage on fresh weight basis [7]. Total chlorophyll content was determined by following the standard procedure on fresh weight basis [8] and results were computed using the standard formulae [9].

Total protein content was estimated by following the standard procedure on fresh and dry weight basis [10]. Total sugars were estimated by phenol-sulphuric acid method on fresh and dry weight basis [11]. Nitrogen content was estimated using 0.5g of sample and digested in conc. H_2SO_4 with K_2SO_4 + $CuSO_4$ + Se mixture in a Kjeldhal flask and distilled in an alkaline medium. The nitrogen content was calculated on dry weight basis [12].

The digestion of castor leaf samples (0.5g) were carried out using tri-acid mixture (HNO_3: $HClO_4$: H_2SO_4 at 10:4:1). The digest was extracted with 6N HCl and volume made upto 100 ml and the extract was used for elemental analysis. Phosphorus, potassium, calcium, magnesium and sulphur contents were estimated as per the standard procedure on dry weight basis [12].

Bio-energetics of eri silkworm

Six eco-races of eri silkworm namely Borduar, Dhanubanga, Khanapara, Kokrajhar, Mendipathar and Titabar were reared using the leaves of DCH hybrid and Local Pink variety of castor from the day of brushing till cocoon spinning maintaining four replications for each eco-race throughout the rearing for determination of bio-energetic indices with 100 larvae in each replication. The bio-energetic indices *viz.,* food consumption (FC), food digestion (FD), consumption index (CI), approximate digestibility (AD) (%), growth rate (GR), efficiency of conversion of ingesta (ECI), efficiency of conversion of digesta (ECD), reference ratio (RR) and metabolic rate (MR) of eri silkworm were worked out both on fresh and dry weight basis [13]; [14]; [15]; [4].

Economic parameters of eri silkworm

The economic parameters *i.e.,* matured larval weight (g), cocoon weight (g), pupal weight (g), shell weight (g), shell ratio (%), silk productivity (cg/day), cocoon yield (kg/100 laying's), shell yield (kg/100 laying's), rate of pupation (%) and fecundity (no. of eggs/laying) were recorded as per the standard procedure.

Correlation studies

In order to know the relationship between the bio-chemical constituents of leaf of castor hybrid/variety with bio-energetic indices and economic parameters, bioenergetics and economic characters of selected eco-races of eri silkworm, the correlation co-efficients were worked out at $p \le 0.05$ and $p \le 0.01$ as per the standard procedure [16].

RESULTS

The results pertaining to correlation between foliar constituents of castor with bioenergetics and economic characters and also correlation between bioenergetics and economic characters in selected eco-races of eri silkworm are tabulated in the form of tables and are explained in the following pages.

Bio-chemical constituents of castor leaf and bio-energetic indices of eri silkworm

The bio-chemical constituents of castor leaf did exhibit highly significant positive relationship with the bio-energetic indices of eco-races of eri silkworm, while it was negative significant relation with food consumption and efficiency of conversion of digesta (ECD) and non-significant with food digestion and reference ratio. Leaf moisture exerts highly significant positive correlation with food consumption, food digestion, consumption index, approximate digestibility, growth rate, ECI, ECD, coefficient of metabolism, reference ratio and metabolic rate. Similar trend was observed for total chlorophyll, total protein (dry), total sugars (fresh), nitrogen, phosphorous, potassium, calcium, magnesium and sulphur with bio-energetic indices, respectively. However, total protein (fresh) and total sugars (dry) found highly significant negative correlation with food consumption, non-significant positive relationship for food digestion, highly significant positive correlation for consumption index, approximate digestibility, growth rate, ECI, significant negative correlation for ECD, co-efficient of metabolism, positively non-significant relationship for reference ratio and highly significant positive relation for metabolic rate (Table 1).

Bio-chemical constituents of castor leaf and economic characters of eri silkworm

The foliar constituents of castor found highly significant positive relationship with economic characters of eco-races of eri silkworm except for matured larval weight, cocoon weight, pupal weight, silk productivity and rate of pupation. The leaf moisture showed significant positive correlation with matured larval weight, shell weight, shell ratio, cocoon yield, shell yield, silk productivity and fecundity, while it was highly significant negative correlation with cocoon weight and rate of pupation. However, leaf moisture was negatively non-significant relation with pupal weight. Similar results were observed with total chlorophyll, phosphorous, potassium, calcium, magnesium and sulphur with bio-energetic indices of eri silkworm. On the other hand, total protein (fresh) and total sugars (dry) found highly significant positive relation with cocoon weight, pupal weight, shell weight, shell ratio, cocoon yield, shell yield and fecundity, while it was negative significant relation for matured larval weight and silk productivity, but it was non-significant with rate of pupation. Total protein (dry) and total sugars (fresh) exerted highly significant positive influence on matured larval weight, cocoon weight, shell weight, shell ratio, cocoon yield, shell yield and fecundity, while, negative significant correlation was observed with silk productivity and rate of pupation and non-significant negative relation with pupal weight. However, nitrogen content of castor leaf registered highly significant positive correlation with cocoon yield, shell weight, shell yield, shell ratio, silk productivity and fecundity, whereas it was negative significant relationship for cocoon weight and rate of pupation, and it was non-significant relation with matured larval weight and pupal weight (Table 2).

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Table 1: Correlation between biochemical composition of castor leaf and bio-energetic indices of eri silkworm

Parameter		Food Consumption	Food digestion	Consumption Index	Approximate digestibility	Growth rate	Efficiency of conversion of Ingesta	Efficiency of conversion of digesta	Coefficient of metabolism	Reference Ratio	Metabolic rate
Leaf moisture		1.000**	1.000**	1.000**	0.999**	0.993**	0.973**	0.974**	0.997**	0.900**	0.901**
Chlorophyll		1.000**	1.000**	1.000**	0.999**	0.992**	0.973**	0.973**	0.997**	0.901**	0.900**
Total protein	Fresh	-0.785**	0.623^{NS}	0.970**	0.946**	0.968**	0.930**	-0.904**	0.903**	0.310^{NS}	0.831**
	Dry	0.999**	0.999**	0.999**	0.999**	0.992**	0.973**	0.974**	0.997**	0.900**	0.901**
Total sugars	Fresh	1.000**	1.000**	1.000**	0.999**	0.993**	0.973**	0.974**	0.997**	0.900**	0.901**
	Dry	-0.809**	0.639*	0.999**	0.978**	1.001**	0.967**	-0.931**	0.950**	0.322^{NS}	0.856**
Nitrogen		1.000**	1.000**	1.000**	0.999**	0.993**	0.974**	0.975**	0.998**	0.899**	0.902**
Phosphorus		0.999**	0.999**	0.999**	0.999**	0.993**	0.974**	0.975**	0.997**	0.897**	0.902**
Potassium		0.999**	0.999**	0.999**	0.999**	0.993**	0.975**	0.975**	0.997**	0.895**	0.904**
Calcium		0.999**	1.000**	1.000**	0.999**	0.992**	0.972**	0.973**	0.997**	0.901**	0.900**
Magnesium		1.000**	1.000**	1.000**	0.999**	0.992**	0.972**	0.973**	0.997**	0.901**	0.900**
Sulphur		0.998**	0.998**	0.998**	0.997**	0.990**	0.970**	0.971**	0.995**	0.901**	0.897**

****: Highly significant (*p≤0.01*)**

Table 2: Correlation between biochemical composition of castor leaf and economic characters of eri silkworm

Parameter		Matured larval weight	Cocoon weight	Pupal weight	Shell weight	Shell ratio	Cocoon yield	Shell yield	Silk productivity	Rate of pupation	Fecundity
Leaf moisture		0.794*	-0.906**	-0.633^{NS}	0.917**	0.919**	0.914**	0.916**	0.911**	-0.910**	0.914**
Chlorophyll		0.864**	-0.988**	-0.519^{NS}	0.995**	0.993**	0.992**	0.993**	0.994**	-0.989**	0.994**
Total Protein	Fresh	-0.721*	0.711*	0.948**	0.945**	0.978**	0.967**	0.990**	-0.864**	0.192^{NS}	0.909**
	Dry	0.898**	1.000**	-0.477^{NS}	1.000**	0.999**	1.000**	1.000**	-0.999**	-1.000**	1.000**
Total Sugars	Fresh	0.737*	0.918**	-0.595^{NS}	0.922**	0.928**	0.929**	0.925**	-0.909**	-0.912**	0.927**
	Dry	-0.759*	0.674*	0.951**	0.960**	0.975**	0.977**	0.995**	-0.891**	0.251^{NS}	0.883**
Nitrogen		0.495^{NS}	-0.718*	-0.596^{NS}	0.752*	0.745*	0.733*	0.739*	0.749*	-0.722*	0.749*
Phosphorus		0.732*	-0.908**	-0.584^{NS}	0.928**	0.924**	0.917**	0.921**	0.927**	-0.911**	0.926**
Potassium		0.866**	-0.989**	-0.518^{NS}	0.995**	0.994**	0.992**	0.993**	0.994**	-0.990**	0.995**
Calcium		0.731*	-0.908**	-0.582^{NS}	0.928**	0.924**	0.917**	0.920**	0.926**	-0.911**	0.926**
Magnesium		0.928**	-0.988**	-0.427^{NS}	0.980**	0.982**	0.986**	0.984**	0.981**	-0.988**	0.981**
Sulphur		0.797*	-0.882**	-0.242^{NS}	0.858**	0.863**	0.869**	0.866**	0.858**	-0.875**	0.861**

***: Significant (*p≤0.05*) **: Highly significant (*p≤0.01*) NS: Non-significant**

Table 3: Correlation between bio-energetic indices and economic characters of eri silkworm

Parameter	Matured larval weight	Cocoon weight	Pupal weight	Shell weight	Shell ratio	Cocoon yield	Shell yield	Silk productivity	Rate of pupatio	Fecundity
Food consumption	0.709**	0.699**	-0.901**	0.705**	0.898**	0.929**	-0.922**	0.924**	0.722**	-0.925**
Food digestion	0.578**	0.573**	-0.853**	0.589**	0.765**	0.813**	-0.802**	0.807**	0.604**	-0.840**
Consumption Index	0.533**	0.529**	-0.834**	0.547**	0.728**	0.779**	-0.771**	0.774**	0.562**	-0.811**
Approximate digestibility	0.662**	0.654**	-0.846**	0.665**	0.815**	0.848**	-0.832**	0.844**	0.677**	-0.859**
Growth rate	0.656**	0.645**	-0.766**	0.652**	0.789**	0.800**	-0.780**	0.796**	0.663**	-0.800**
Efficiency of conversion of Ingesta	0.661**	0.653**	-0.846**	0.664**	0.815**	0.849**	-0.832**	0.844**	0.677**	-0.859**
Efficiency of conversion of digesta	0.578**	0.573**	-0.853**	0.589**	0.765**	0.813**	-0.802**	0.807**	0.604**	-0.840**
Coefficient of metabolism	0.661**	0.653**	-0.846**	0.664**	0.815**	0.849**	-0.832**	0.844**	0.677**	-0.859**
Reference Ratio	0.708**	0.703**	-0.901**	0.715**	0.857**	0.899**	-0.889**	0.896**	0.730**	-0.904**
Metabolic rate	0.466*	0.461*	-0.726**	0.483*	0.523**	0.656**	-0.629**	0.652**	0.479*	-0.690**

***: Significant ($p \leq 0.05$) **: Highly significant ($p \leq 0.01$)**

Bio-energetic indices and economic characters of eri silkworm

Bio-energetic indices of different eco-races of eri silkworm were found highly significant positive correlation with economic parameters except for pupal weight, shell yield and fecundity where it showed highly significant negative correlation. Food consumption of eri silkworm was found highly significant positive correlation with matured larval weight, cocoon weight, shell weight, shell ratio, cocoon yield, silk productivity and rate of pupation, while it was highly significant negative correlation with pupal weight, shell yield and fecundity. Similarly, food digestion, consumption index, approximate digestibility, growth rate, ECI, ECD, co-efficient of metabolism, reference ratio and metabolic rate had relationship with economic characters (Table 3).

DISCUSSION

The current investigation has been conducted to find out whether there is any relationship between foliar constituents of castor leaf of DCH-177 hybrid / Local Pink variety with that of bio-energetic indices and economic characters of selected eco-races of eri silkworm. The study revealed that leaf moisture, chlorophyll, total sugars, nitrogen, phosphorous, potassium, calcium, magnesium and sulphur did exert highly significant positive influence on food consumption, digestion, CI, AD, growth rate, ECI, ECD, co-efficient of metabolism, reference ratio and metabolic rate, while total protein showed positive non-significant correlation on food digestion, reference ratio, pupal weight and rate of pupation. However, the bio-energetic indices register highly significant positive response towards economic parameters of selected eco-races of eri silkworm.

Growth, development and economic characters of eri silkworm are governed by the chemical constituents of castor leaves used for rearing [3]. The foliar constituent's *viz.,* leaf moisture, total carbohydrates, total amino acids, phosphorus, potassium, calcium, magnesium and sulphur of castor genotypes showed positive significant relationship with larval, cocoon and grainage parameters, indicating that foliar constituents have a strong bearing on larval development, cocoon production and grainage parameters of eri silkworm [1].

The relationship between quality parameters of castor genotypes *viz.,* moisture, total chlorophyll, total carbohydrate and crude protein contents were found non-significant relation with consumption indices namely food consumption, food digestion, CI, AD, GR, ECI and ECD both on fresh and dry weight basis. Non-significant correlation was also found between elemental composition of leaves of castor genotypes (nitrogen, phosphorus, potassium, calcium, magnesium and sulphur) with consumption indices of eri silkworm *viz.,* food consumption, food digestion, CI, AD, GR, ECI and ECD except between calcium and magnesium with food consumption on fresh and dry weight basis [17].

The relationship between quality parameters of castor genotypes namely moisture, total chlorophyll, total carbohydrates and crude protein with economic traits of eri silkworm *viz.,* rearing (matured larval weight, total larval duration, ERR, cocoon and shell yield), cocoon (cocoon weight, shell weight, shell ratio, silk productivity, fibroin and sericin). However, elemental composition of castor genotypes was found to have non-significant relationship with rearing parameters of eri silkworm except between calcium and magnesium with ERR. Significant positive relationship did exist between cocoon traits namely cocoon weight, shell weight, shell ratio, silk productivity and sericin with elemental composition of castor genotypes namely nitrogen, phosphorus, potassium, calcium and sulphur [18].

The correlation between bio-chemical constituents of castor leaf *viz.,* moisture, total chlorophyll, crude protein and total carbohydrates had non-significant relation with economic parameters of eri silkworm (rearing, cocoon and grainage parameters). However, crude protein and total carbohydrates showed positive significant relationship with ERR, cocoon yield, shell weight and shell yield, shell ratio and silk productivity; total carbohydrates with cocoon weight, fibroin and rate of pupation. However, larval duration showed negative significant relationship with total carbohydrate and major nutrient contents of castor genotypes (nitrogen, phosphorus and potassium) had non-significant relationship with economic parameters of eri silkworm except between nitrogen with larval duration, ERR, cocoon yield, shell weight, shell yield, shell ratio, silk productivity and fecundity. Similarly, secondary nutrients (magnesium and sulphur) had no relationship with economic parameters of eri silkworm. However, calcium content was found to have positively significant relationship with larval weight, ERR, cocoon weight, cocoon yield, shell weight, shell yield, shell ratio, silk productivity, fibroin, rate of pupation, rate of moth emergence and fecundity [5].

The relationship between bio-chemical constituents of selected castor genotypes namely leaf moisture, total chlorophyll, crude protein and total carbohydrate contents were found non-significant relation with bio-energetic indices of eri silkworm viz., food consumption, food digestion, CI, AD, GR, ECI and ECD both on fresh and dry weight basis except between nitrogen with ECI and ECD both on fresh and dry weight basis [19].

CONCLUSION

From the study it can be inferred that, bio-chemical components of castor leave of DCH-177 hybrid / Local Pink variety had profound influence on bio-energetic indices (consumption and utilization indices) in selected eco-races of eri silkworm, which in turn had positive significant relation with economic characters of eri silkworm.

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