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EFFECT OF FOLIAR APPLICATION OF ESSENTIAL NUTRIENTS ON THE REARING PERFORMANCE OF OAK TASAR SILKWORM DURING SUMMER CROP

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Abstract
In Oak Tasar culture, one of the main reasons for failure of summer crop is lack of quality leaves for rearing. Foliar application of urea and micronutrients was administered at standard doses to the under-surface of *Quercus serrata* leaves to study the comparative performance of *Antheraea proylei* silkworms fed on those leaves during summer season. Results indicated that the larvae fed with 1.5% urea-treated leaves performed best with respect to rearing and cocoon parameters with 34.7% E.R.R. followed by 3% micronutrient treatment which showed 29% E.R.R as against control. There was a significant improvement in the growth rate and a subsequent reduction in larval duration by 3 days in case of urea-treatment. There is a further need to assess seasonal changes in chemical composition of food plants, so as to provide optimal nutrition to the Oak Tasar silkworms, which will help in improving the productivity of Oak Tasar industry.
Keywords: *Quercus serrata; Antheraea proylei;* foliar application; micronutrients; silkworm

1. Introduction
In India, nearly 2 million hectares of land is covered by Oak species (Family:Fagaceae) all along the temperate sub Himalayan region extending from Jammu and Kashmir in north west at 1200-3500m ASL to Manipur in North-east at 600-1800 m ASL. The common Indian Oak species growing in these regions are *Quercus serrata*, *Lithocarpus dealbata*, *Quercus griffitthi*, *Quercus semicarpifolia*, *Quercus incana*, *Quercus himalayana*, etc. *Quercus serrata* is the dominant species throughout the North eastern states as it is comparatively fast growing than other Oak species produces high quality firewood and the most suited food plant for rearing of the oak tasar silkworm, *Antheraea proylei*. Oak tasar culture in India is a recent practice which initiated with the synthesis of the *Antheraea proylei* during 1970s. Introduction of this new sericiginous interspecific hybrid which is a cross between the Indian species *A.roylei* and the Chinese species, *A.pernyi* (Jolly *et al*, 1969) heralded a new chapter in the field of Indian sericulture. Oak tasar culture opened up new vistas to mould the economy of weaker sections of the society.

Manipur state lies in a hilly region with an area covering 22,327 square kilometres. The abundant availability of Oak flora and salubrious climatic conditions soil and socio-economic conditions makes this region ideal for Oak tasar culture. Although sericulture in Manipur is an age old tradition, the practice heightened to a commercial level with the commercial exploitation of *Antheraea proylei* in 1970. By 1979, Manipur alone produced around 2.5 crores of cocoons. However, several adverse seasons such as poor management practices, fluctuating environment, disease incidences and poor quality leaves have led to the decline of Oak tasar industry in recent years. Presently, only mono-crop rearing is conducted successfully during spring, but summer/autumn crops continue to be inconsistent till present date.

Success of Oak tasar industry largely depends on increased productivity of quality foliage per unit area and proper management practices. It has been observed that the quality of *Quercus serrata* declines rapidly from spring to summer seasons rendering it unsuitable for summer crop rearing. This can be attributed to the high temperature and humidity prevailing in this region during summer season and consequent over maturity of the leaves. Although light pruning and top-clipping methods are carried out, the leaf quality is inferior and growth rate is compromised. The silkworm rearing on such plant is hardly met with success. In addition, farms where the same plants are utilized year after year for rearing purpose require adequate input of fertilizers, failing which leaf quality remains unfit for silkworm consumption and the desired leaf cocoon and silk productivity cannot be achieved. Thus, it becomes imperative to fortify the plantations with the essential nutrients to achieve desired growth during unfavourable seasons of the year. Pandey (1995) reported that nutritive value of leaf is a major contributing factor for survival of non-mulberry silkworms. Somasundaram *et al* (1996) opined that quality of leaves play an important role in cocoon production. Role of NPK fertilizer and secondary nutrients in improvement of leaf yield and larval and cocoon characters was elucidated by Sinha *et al* (2009) and Marepally & Banerjee (2015). On the other hand, Bose *et al* (1994) observed that micronutrients accelerated the growth of mulberry silkworms and improved the quality of cocoons and silk. Keeping the above aspects in view, the present investigation was taken up to study the rearing performance and cocoon parameters of the Oak tasar silkworms feeding on *Quercus serrata* leaves sprayed with macro and micronutrients during summer season.

2. Materials and Methods

2.1 Biomaterial utilized

Antheraea proylei moths that emerged during last week of May were processed for obtaining the disease free layings for the present experiment.

2.2 Disinfection and incubation of eggs

The eggs were disinfected by immersing them in 0.5% NaOH for 30 seconds followed by rinsing in distilled water. Then, they were soaked in a solution containing equal volumes of 3% HCl and 3% Formalin for 10 minutes. The eggs were air-dried and then incubated -at 24°C inside B.O.D. incubator till they hatched.

2.3 Plants materials

A total of 90 plants of *Quercus serrata* were selected in the plot with 1.2m × 1.2m spacing at RTRS campus, Imphal, Manipur. During selection, attention was given to select healthy plant with uniform growth having 5 feet height and average growth of 1 foot. All the plants were subjected to lightly pruning through top clipping method during the last week of May.

2.4 Foliar treatments

1.5% Urea spray– Urea solution was prepared with 15 grams of Urea powder diluted to 1000ml water to prepare 1.5% concentration. Urea solution was sprayed to the pruned plants on freshly sprouted leaves to 30 plants. 20 days prior to brushing. Spraying was limited to lower surface of the leaves to enable quick absorption.

Micronutrient spray– 'Plantaid®' which consists of six micronutrients - zinc-3%, copper-0.1%, manganese-0.2%, boron-0.2%, molybdenum-0.005%, magnesium-0.2% was diluted @ 100ml in 3.33 litre of water and sprayed during morning hours on the under-surface of freshly sprouted leaves of 30 selected plants.

2.5 Disinfection of rearing site

The whole plot which was selected for the experiment was disinfected with 98% slaked lime and 2% bleaching powder mixture 4 days prior to commencement of rearing.

2.6 Indoor Rearing

Indoor rearing of chawki silkworm larvae was conducted using glass bottles. Prior to rearing, disinfection of the rearing room was done with 2% Formalin solution. The glass bottles were disinfected with 0.04% Sodium hypochlorite (NaOCl) solution. Worms that hatched in 48 hours duration were brushed onto the tender leaves with the help of squirrel hair brush in order to avoid the injury. 98% slaked lime and 2% bleaching powder mixture was sprinkled around the bottles as a prophylactic measure. During the 1st and 2nd instar larvae, shoots with tender leaves from the treated and control plots were collected and reared separately in three replications. The leaves were rinsed with 0.02% NaOCl and then allowed for feeding. During molting, the room was kept well-aerated and the worms were allowed to molt on the dry shoots.

2.7 Outdoor rearing

Third instar onwards, the silkworm larvae were transferred outdoors and reared till spinning. Plants with profuse leaf growth containing tender to medium leaves were selected. Worms were transferred to their respective treated plants and foliar spray of 0.02% NaOCl was administered to the plants prior to transfer of worms and continued every alternate day. Nylon nets were put up around the plants to prevent the attack of pest and predators. The worms were transferred to new plants by cutting the twigs whenever required. Larval weight was recorded at every instar. Outdoor temperature and relative humidity was observed twice a day, at 10 A.M. and 4 P.M. After 5 days of spinning, the cocoons were harvested and assessed for the quantitative parameters.

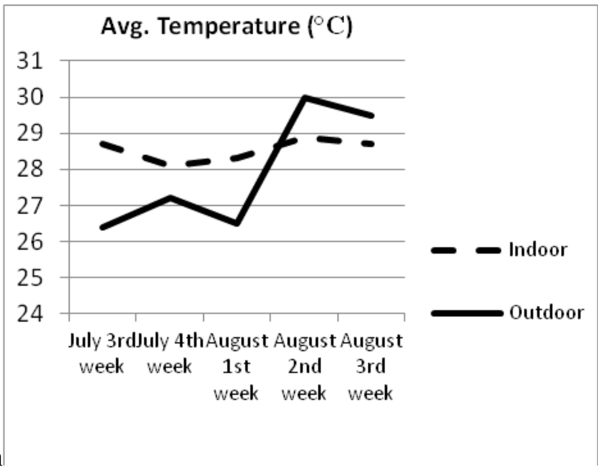
3. Results

The meteorological data, viz., average temperature and relative humidity was recorded from the date of brushing till the larvae attained spinning stage and the same is presented in Table 1 and Figures 1a and 1b.

Table 1: Meteorological parameters recorded during rearing period of summer crop at RTRS, Imphal

Week	Average Temperature (°C)		Average Relative humidity (%)	
	Indoor	Outdoor	Indoor	Outdoor
July 3rd week	28.7	26.4	75	80
July 4th week	28.1	27.2	75	82
August 1st week	28.3	26.5	75	85
August 2nd week	28.9	30	76	80
August 3rd week	28.7	29.5	76	77

Note: Chawki rearing was conducted indoor till the 4th week of July, 2016



a

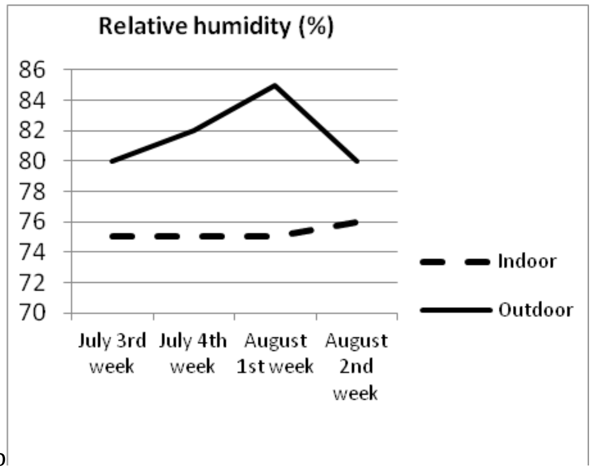


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Fig.1 (a & b): Line graphs showing average temperature and average relative humidity prevailing during summer crop rearing.

The chawki stage (I and II instars) was reared indoors and the average temperature ranged from 28.1°C to 28.7°C and the relative humidity remained constant at 75%. Third instar onwards, the rearing of the larvae was taken up in outdoor condition where the average temperature ranged from 26.5°C to 30°C and the relative humidity fluctuated between 77% and 85%.

The larval growth was assessed at each instar and the data is presented in Table 2 and Figure 2 (a-e).

Table 2: Growth rate (mean±S.D.) of *Antheraea proylei* under different treatment and control conditions during summer season

Larval Instar	Larval Weight (g)			F-value
	Control	Urea	Micronutrient	
I	0.041±0.001	0.051±0.001	0.047±0.001	45.8**
II	0.199±0.001	0.258±0.002	0.227±0.002	37.65**
III	1.202±0.003	1.321±0.003	1.304±0.004	6.27*
IV	14.014±0.012	15.190±0.008	14.184±0.010	1327.65**
V	20.542±0.028	25.429±0.025	23.524±0.019	627.25**

Note: ***p<0.05; ** p<0.01**

1st Instar: During 1st instar, the larvae fed with urea treated leaves weighed 0.051g whereas the larvae fed with micronutrient treated leaves weighed 0.047g. The larvae under control conditions weighed the least with a value of 0.041g. The statistical analysis shows that the p-values were significant ($p<0.01$) at this stage.

2nd instar: During the 2nd instar, the larval weight recorded was 0.258 g for Urea, 0.227 g for micronutrient and 0.199 g for control. Maximum weight gain was seen in case of the larvae fed with urea treated leaves.

3rd instar: It was seen that the larvae fed with Urea treated leaves gained maximum weight of 1.321 g, followed by the larvae fed with micronutrient treated leaveswith1.304 g while control larvae weighed only 1.102 g.

4th instar: During fourth instar, the larval weight in two treatments and control ranged from 14.014 g to 15.190 g where the larvae fed with urea treated leaves showed the highest weight and control lowest and the larvae fed with micronutrient treated leaves showed intermediary value of 14.184 g.

5th instar: During V instar, the larvae fed with urea-treated *Quercus serrata* leaves weighed 25.429 g, whereas those fed with micronutrient-treated leaves weighed 23.524 g and control weighed the lowest with 20.542g. The differences among the treatments and control were highly significant ($p<0.01$) at this stage.

There was no difference observed in the larval duration of the treatments and control during 1st to 4th instars. But, in 5th instar, the larvae fed with urea-treated leaves exhibited a shorter larval duration than in micronutrient treatment with a difference of 2 days. There was a difference of 3 days in larval duration with urea treatment and control.

The rearing performance was assessed for all the treatments and control and the comparison is presented in Tables 3 & 4 and figures 3-5.

Table 3: Mean rearing performance of *Antheraea proylei* under different treatments

Treatment	LW (g)	ERR (%)	CW (g)	PW (g)	SW (g)	SR
Control	20.54±0.38	10.6±0.67	5.91±0.09	5.22±0.09	0.69±0.01	11.67±0.09
Urea	25.43±0.30	34.7±0.88	6.67±0.09	5.87±0.09	0.80±0.01	12.05±0.25
Micronutrient	23.52±0.49	29±1.00	6.42±0.10	5.69±0.08	0.77±0.04	11.99±0.44

Table 4: Percent improvement in economic characters of *Antheraea proylei* in treatments over control

Treatment	LW	ERR	CW (g)	PW (g)	SW (g)	SR
Control	-	-	-	-	-	-
Urea	23.81**	227.36**	12.86**	12.45**	15.94**	3.26
Micronutrient	14.51**	173.58**	8.63*	9.00*	11.59*	2.57

Note: All values are in percentage, *=p<0.05; **=p<0.01

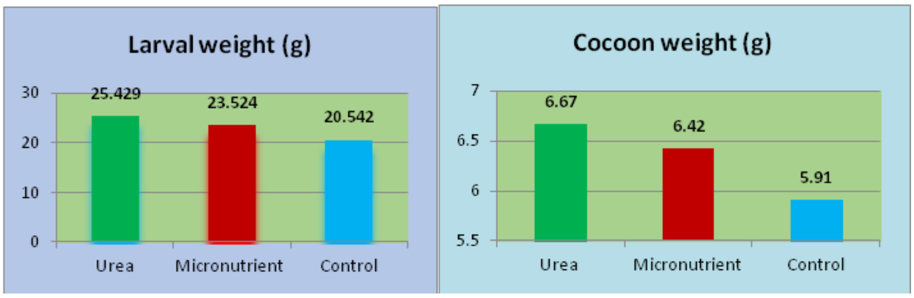

Fig 3. Histogram showing the larval weight and cocoon weight of urea, micronutrient and control

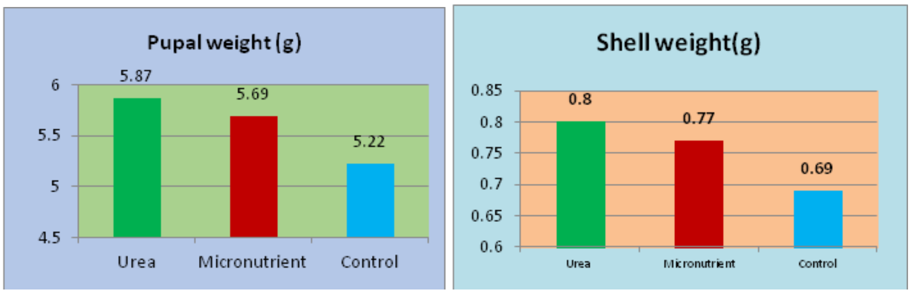

Fig.4 Histogram showing the pupal weight and shell weight of urea, micronutrient and control

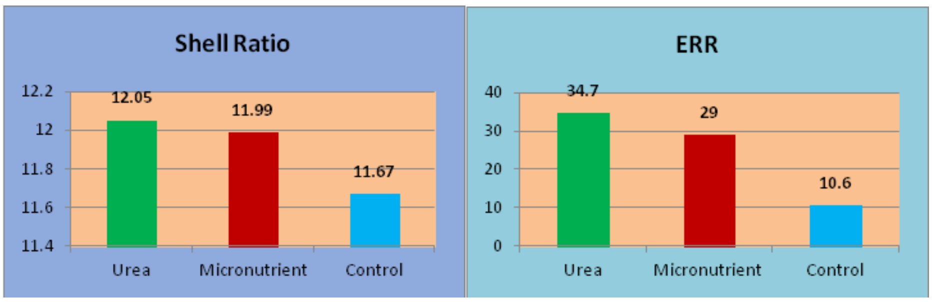

Fig.5 Histogram showing the shell ratio and ERR of urea, micronutrient and control

Larval weight: The larval weight recorded in case of urea treatment was highest among treatment and control with a value of 25.43 g, followed by micronutrient treatment with 23.81% and 14.51% respectively.

Effective Rate of Rearing: The urea-treated batch showed highest ERR of 34.7%, while in micronutrient–treated batch, it was 29%. The lowest ERR was observed for control batch with 10.6 %. Maximum improvement in ERR of 227.36% was noticed in Urea-treated batch.

Cocoon weight: The urea treated batch showed highest cocoon weight of 6.67g, while micronutrient-treated batch was 6.42g and the lowest cocoon weight was shown by the control batch 5.91g. Maximum improvement of 12.86% was exhibited by urea-treated batch over control.

Pupal weight: The pupal weight of the urea treated batch shows highest which is 5.87g with 12.45% improvement over control, while micronutrient-treated batch weighed 5.69g and the lowest pupal weight was observed for control batch (5.22g).

Shell weight: The shell weight ranged from 0.69g to 0.80g, with the highest being in urea-treated batch and lowest in control while micronutrient batch recorded an intermediary value of 0.77g. Significant improvement was noticed in the treatments for this trait.

Shell ratio: The shell ratio in the treatment and control batch varied from 11.67 to 12.05. Urea treated batch recorded highest SR of 12.05 followed by micronutrient treated batch with 11.99. The lowest SR was observed for control batch. The percent improvement in urea and micronutrient treatments were 3.26% and 2.57% ($p>0.05$).

The overall result brings out a clear picture that the larvae fed with urea treated leaves excelled in performance of all the cocoon traits closely followed by the batches fed with micronutrient-treated leaves, while the performance of the control batch remained the lowest.

4. Discussion

Quercus serrata is the primary food plant for *Antheraea proylei*. Hence, the quality of the leaf is extremely important for proper growth and development of the silkworms that would reflect in their fitness and productivity characters. It is observed that second crop rearing during the month of June-July is inconsistent due to unfavourable abiotic conditions and over maturity of the leaf. The leaf becomes more fibrous with reduced carbohydrate and protein content. The present study on the impact of foliar spray of macronutrients and micronutrients on the rearing performance of *Antheraea proylei* during summer crop suggests that leaf quality played a crucial role in the healthiness and productivity of Oak tasar larvae. Jolly *et al* (1971) reported that healthy growth of silkworm and ultimately the economic traits are largely influenced by the nutritional status of leaves fed to the worms. Kibazaka (1932) suggested that there exists a positive relationship between food plants and cocoon character of Japanese and Chinese Oak tasar silkworm. Federov (1941) studied the nutritional quality of Oak leaves and suggested their significant influence on rearing performance of Chinese Oak tasar silkworm. Fortification of the Oak leaves with urea by foliar spray resulted in considerable improvement in not only the larval growth rate but the overall efficiency and performance of the larvae during summer season. Kozhanchikov (1951) studied the significance of seasonal changes in the chemical composition of food plants and its effect on the nutrition of the oak tasar silkworm (*Antheraea pernyi*) and certain other Lepidoptera. Efficient use of urea and/or Tricon® helped to improve the chemical composition and nutrition qualities of leaves in mulberry (Khyade & Sakdeo, 2012). NPK fertilizer was found to be more efficient in increasing the total soluble proteins, free amino acids, total soluble sugars, total reducing sugars and chlorophyll content of *Terminalia arjuna* leaves and also improved the larval and cocoon characters of *Antheraea mylitta* Drury (Daba T.V.) (Marepally & Banerjee, 2015). Our findings suggest that micronutrient treatment followed closely after urea treatment in increasing the productivity of Oak tasar silkworm. Sinha *et al* (2009) studied the effect of different secondary nutrients indifferent doses on the leaf yield and biochemical constituents of *Terminalia tomentosa* and reported that secondary nutrients have promotory effect in increasing the leaf yield and foliar constituents of *Terminalia tomentosa*. Bose *et al* (1994) opined that micronutrients accelerated the growth of silkworm through orientation of physiological activity and hereby improved the quality of cocoons and silk. It was reported that foliar spray of urea along with different doses of NPK fertilizers significantly increased leaf yield and nutrients like moisture content, protein, sugar, reducing sugar and starch in both tender and mature leaf (Dhiraj & Kumar, 2012). Dixon *et al* (1984) and Ghosh & Srivastava (1994) studied the responses of white oak seedlings to foliar applications of fertilizer and plant growth regulators and suggested that foliar mist applications of plant growth regulators in combination with foliar fertilizer solutions promote oak seedling root shoot growth. Foliar applications of micronutrients like urea solutions have been found to increase yield by 27% in different mulberry varieties (Qaiyyum *et al*., 1991).

An important finding from the present investigation was that better leaf quality with urea treatment led to shortening of larval duration, which is very advantageous from the point of cost effectiveness of silkworm breeding programmes. However, further investigations are required to evaluate if there is any qualitative differences in Oak Tasar cocoon and silk brought about by higher nutritional inputs. There is also a need to assess seasonal changes in chemical composition of food plants, so as to provide optimal nutrition to the Oak Tasar silkworms, which will help in improving the productivity of Oak Tasar industry.

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