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Silkworm Yield Prediction in Attibele Region using Machine Learning Technique

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Abstract*: Sericulture is the processes of cultivation of silkworms to produce cocoons which are used for the production of silk or to produce eggs. This research work is carried out with respect to the Attibele region (Karnataka State in India). There are various species of silkworms that are grown in the world, and the yield of silk varies with climatic change. Why climatic changes important for rearing of silkworms? Because they are very sensitive for temperature and humidity fluctuations. For example if the temperature is high and humidity is low or the temperature is low and humidity is high, the silkworms become unhealthy. In this paper we have calculated the climatic conditions that is to be maintained in the future for obtaining the optimal yield of the silkworms. The work also aims to provide the remedies to be taken for the betterment of the production, both in terms of farm-land and cocoons.

Keywords: Silkworm Yield Prediction, Decision Tree Regression, Black Box, Savayava krishi.

I. INTRODUCTION

Sericulture, an agro-based industry which oversees raising of silkworms with the ultimate objective of silk production. This method of farming has been practiced by almost 60 countries, among which India ranks 2nd and among the states Karnataka ranks 1st [1]. Sericulture has become the root for social and economic progress of India. This type of farming is ideal in marginal land, which has the soil of pH 6.5 to 6.8. Mulberry can be grown as an intercrop i.e. involving growing of two or more crops in proximity. The scientific name of the silk worm is Bombyx mori, which is reared in a mass scale on mulberry leaves, to get the raw silk from the cocoons [2]. There are different types of silkworms that are reared in India: Univoltines, Bivoltines and Polyvoltines [3]. Univoltines and Bivoltines are superior races in terms of quality and quantity and Polyvoltines are superior in terms of hardness and survival. Bivoltine eggs are popular among certain rural areas of Karnataka such as Krishnarajapet, Anekal, Kunigal, Magadi, Siddlaghatta, Kolar, Kanakapura, Devanahalli, Chamrajanagar, Chintamani, Bagepalli, Srinivasapura, Chikkaballapur, Malur, Bangarpet [4]. September-February are the most favorable months for rearing of Bivoltine and during the rainy season, August- October, rearing of PMxBivoltine is recommended [5].

Silkworm production contributes 92 percent of the total silk produced [6]. It is very much essential to grow healthy mulberry leaves (food for silkworms) at the same temperature and humidity throughout the year, for the better rearing of silkworms. The cultivation region of mulberry crop also plays a major role in deciding the production of the end-product, cocoons-raw silk.

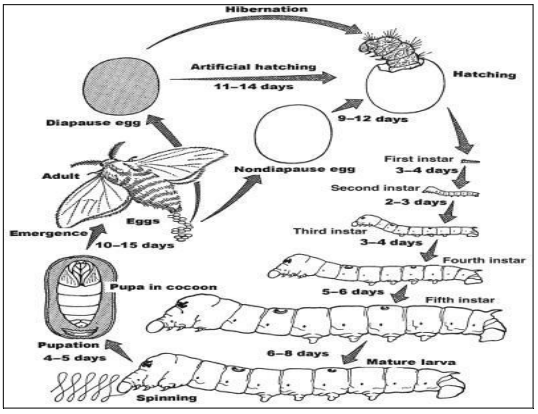

Fig. 1. Life Cycle of Silk worm

"Fig. 1" represents the life cycle of the silkworm where [6], firstly, male and female moths mate, and then the female moth lays 350-400 eggs [6]. The eggs hatch within 10-12 days under normal temperature and then first moulting takes place within 2-3 days [6]. After which they are fed with mulberry leaves. The complete life cycle of silk worm is for 24-28 days which includes 4 moult stages and spinning into a cocoon takes place by the end of 24-28 days [6]. The fluctuation of the yield depends on the temperature and humidity of the silk house, as well the mulberry leaves that have to be well-maintained for production of cocoons. Within this time period, there are 5 instars, which are developmental stages of the larvae of the silkworms. At every stage of growth of silkworm, a proper temperature has to be maintained for its healthy development. The eggs of the silkworm are hatched within 8-10 days [6].

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II. LITERATURE REVIEW

The silkworm's eggs quality plays a major role in the lifecycle of the silkwor

The rearing dimensions of silk house:

- The height of the wall should be 10 inches at the sides and 4 inches at the center.
- The house should be of 75 feet in length and 30 feet in width, having 12 windows, each of 4 feet in height and 2 feet in width and 12 ventilation windows of 2*2 feet.
- There should be a storage room to store and/or to process the leaves.
- The room should be disinfected before the worms are brought in.
- Wire mesh should be used for covering the doors and windows of the room to avoid Uzi-fly.
- The necessary equipment like heaters, humidifiers, coolers etc., should be made available.
- The roof of the silk house should be covered with Asbestos or RCC.
- The doors should be built facing north – south direction to reduce direct sunlight.
- During the summer, the rooftop should be covered with coconut leaves, to maintain the desired temperature.

The silk house should be surrounded with shady trees to protect the house from higher temperatures [7]. Spacing of the plant in mulberry cultivation depends on the soil and the region of cultivation. Between each lane, the spacing should be about 10 mts and the spacing between each plant should be 3mts [8]. For every instar, the temperature should be modulated as given in Table 1 [7].

Table- I: Instar Temperature

Instar	Temperature Celsius	RH%
I	27-28	85-90
II	27-28	85-90
III	26-27	75-80
IV	25-26	70-75
V	25-26	70-75

The temperatures are artificially maintained by usage of sprinklers, to cool the house, in case of hot conditions and in cases to raise the temperature, charcoal or humidifiers are used. Poor ventilation in the house may lead to high humidity and accumulation of various gases that harm the growth of silkworm. The bed requirements to rear the silkworms are as mentioned in Table II [7].

Table- II: Bed Requirements

Instar	Multivoltine (sqm/sqft)	Bivoltine (sqm/sqft)
I	1.50/15	1.75/17.5
II	4.50/45	5.25/52.5
III	9.00/90	12.00/120
IV	24.00/240	133.00/330
V	50.00/500	77.00/700

A. Methodology

The improved bivoltine hybrids namely, CSR2 x CSR4 and double hybrid (Krishnaraja) are recommended under Institute Village Linkage Programme (IVLP) as they produce more yields and are comparatively more resistant to humidity and temperature [9].

The conventional method of rearing silkworms, which is commonly adopted by farmers, is known as industrial agriculture. Concentrated animal feeding operations, heavy irrigation and concentrated monoculture are some of the industrial agriculture methods used my farmers for the production of silkworms [10]. The eggs of the moth are given to the farmers, prior to which the eggs are placed in the incubation center/chamber under room temperature of $25^0 \pm 1^0$C and the humidity of the chamber is maintained at 70-80%. This ensures the uniform development of the embryo, thereby increasing the percentage yield of hatching.

During every seasonal change, the methods adopted for the production of silkworms and the maintenance of the farmland also changes. At every seasonal change, there is a fluctuation in the yield of silkworms. The fluctuation in the yield is affected during the first few weeks of both summer and winter. During summer rearing the silkworms is a challenging task. However, the yield of silkworms during spring and autumn is moderate.

Prior to cultivation of the plant, the farm should be free from any chemical fertilizers. If the method of farming is Savayava krishi, then the dimensions should be 5*5" between the plant lanes and 3*9" between plants. Instead of chemical fertilizers, we can make jeevamrutham and use it.
Jeevamruthm Recipe:

- 200Ltr water
- 5Ltr-10Ltr Cow Urine. (1 cow gives 2Ltr urine)
- 10 kg Cow dung (should be fresh)
- 1 Kg Jaggery / Vellam
- Or 4Ltr - Sugarcane juice
- Or 10Kg small pieced Sugarcane
- Or 1Kg Sweet Fruit Pulp
- 1Kg – Toor Dal or Besan (best)
- 100Gm – farm's soil.

In a 200Ltr barrel mix all the ingredients and rotate it in a clockwise direction in morning and evening for 7 days. After which this liquid can be given to the plants directly or mix this liquid to the water that flows in the lanes. Normally the plants life span is 20-25 years, it can be increased to 30-35 years by following this method.

B. Silkworm Maintenance for 28days

- The first process is getting the silkworms that are placed in a black box as shown in the "Fig. 2" from the government [11]. Each black box will contain 7-8 trays on which the worm eggs are placed.

Fig. 2. Black Box

These worms are generally 4-5 days old and are much smaller in size. The growth of these worms is taken care of by the farmers. They feed the worms with the crushed and grinded mulberry leaves. And the mulberry leaves that has to be fed, should be brought from the farm land, on the same day of feeding. The farmers feed the worms twice a day or once every morning. Generally, the axillary leaves (parental leaves) are fed to the worms, due to the smooth texture of these leaves.

- During their first molt (shedding of the skin), that happens on 4th/5th day, the worms stop feeding on the leaves. Then they resume their feeding within a couple of hours [12].
- During the second molt the worms are fed with apical leaves (shoot leaves). On the 4th/5th day of this stage (second instar), the molting happens and they resume their activity of feeding within the next 40 hours [12].
- During the third molt (7 days), the worms are initially fed with shoot leaves for the first three days, followed by feeding with branches consisting of 22-24 leaves for the next four days [12].
- The worms are fed with mulberry leaves till the 26th – 28th day. After this stage, the mesh tray as shown in "Fig. 3" [13], is placed on the worms for the process of spinning that takes place for 7-8 days [12].

Fig. 3. Mesh tray

This results in the formation of a cocoon. Sometimes the mulberry leaves are damaged due to heavy rains. In such cases, the availability of the leaves is less, which makes the farmers difficult to rear. Consequently, the yield in the production of cocoons also decreases

III. METHODOLOGY

A. Analysis of conventional method of dataset

The dataset is collected from Attibele Cocoon Market Center, where all the farmers of that region get their cocoons to submit to the government. The submitted cocoons are calculated in terms of number of kilograms, for the produced number of silk cocoons that a farmer has taken for that month. These details are recorded on a daily basis and then the cocoons segregated and taken by Private and government organizations for both Reeling (to produce silk) and Seeding (to make eggs).

B. Proposed Method

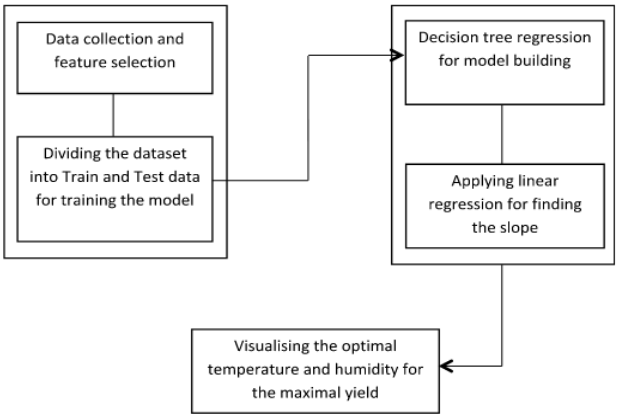


Fig. 4. Methodology Diagram

In the proposed system as shown in "Fig. 4", the raw data set is gathered and subjected to imputation methods and refinement of data is performed. The data is then subjected to feature selection and is converted into the desired format. Further, it is subjected to decision tree regression technique and linear regression technique. From this, a predictive model is developed.

The performance of the yield is compared with number of cocoons, temperature, and humidity and is tested [14]. This method splits the data set into a tree like structure with two or more branches. Leaf nodes and the decision nodes represent the final results of the method applied in the model. Every new node that is created is called a branch and each branch has a single value [14]. Every node that is created has a rule which makes the prediction for the selected features.

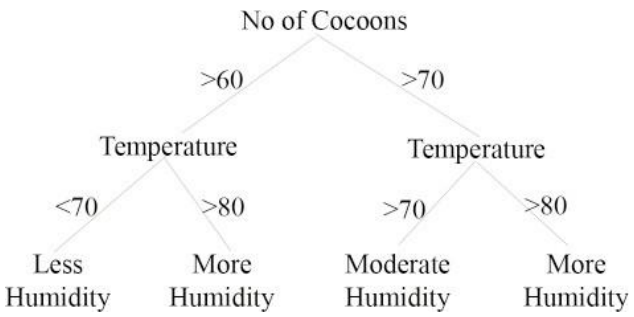


Fig. 5. Decision Tree

In "Fig. 5", the temperature and humidity represents the leaf nodes. At every level, a rule is applied. For example, the maximum number of cocoons is obtained when the temperature is greater than 70 °F and when the humidity is greater than 60%. The rules applied in the method helps in making the predictions [14].

Linear Regression technique forms an association between one or more independent variables (X) and dependent variables (Y) by employing the best fitted straight line method

$$Y = a + bX \quad (1)$$

Where, 'Y' is the dependent variable, 'X' is the independent variable, 'b' is the slope and 'a' is the y-intercept [15]. This technique is used for finding the slope between number of cocoons versus humidity as shown in "Fig 6" and number of cocoons versus temperature as shown in "Fig 7". The dataset collected for the analysis are shown in Table III.

Table- III: Dataset Features

Instar	Multivoltine (sqm/sqft)
1	Month
2	Batches
3	Number of Cocoons
4	Kilogram
5	Seeding: Number of batches
	Seeding: Number of Cocoons- Government
	Seeding: Number of kilogram - Government
6	Number of Cocoons – Private
7	Number of kilogram – Private
8	Reeling: Number of batches
	Reeling: Number of Cocoons- Private
	Reeling: Number of kilogram - Private
9	Temperature
10	Humidity

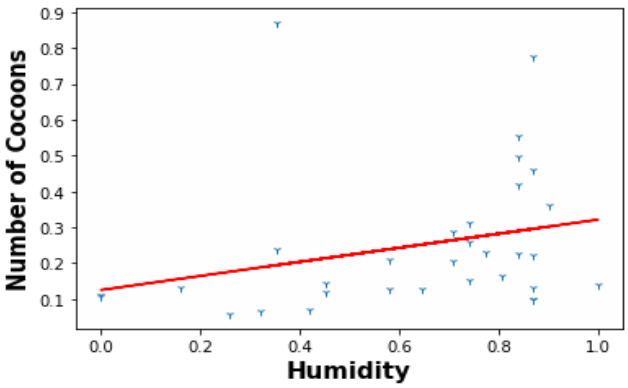


Fig. 6. Number of Cocoons versus Humidity

Months = April-March; Batches = the yield received by the government from every farmer at Attibele region; Number of cocoons = total number of cocoons of the respective month and batch; Kilograms = number of kilograms of cocoons of the respective month. Seeding = cocoons taken for production of eggs (mating). For this process, both government and private collect the cocoons; Reeling = cocoons taken for the extraction of silk threads. Here, the private people mainly collect cocoons; Temperature and Humidity, which are maintained in the respective months for the healthy growth of worms.

C. Feature Selection

Table- IV: Selected Features

Sl. No	Features
1	Number of Cocoons
2	Temperature
3	Humidity

The selected features in Table IV are used, in the analysis of the yield with respect to climatic change. The other features like, month, batches, seeding and reeling mainly help in determination of silk and is helpful in determining the number of cocoons that can be considered in the respective month, for the production of silkworm eggs or in the production of silk.

Model is created to check the relevance of the selected features. The selected features shows that in every month, for each batch, during the respective season, the optimum temperature and optimum humidity has to be maintained for the production of the optimum yield of silk cocoons.

The correlation between each selected feature is the number of eggs, temperature and humidity.

Table-V: Correlation Matrix

	Number of Cocoons	Humidity	Temperature
Number of Cocoons	1.000000	0.573392	0.610505
Humidity	0.573392	1.000000	0.123851
Temperature	0.610505	0.123851	1.000000

Table V shows the positive correlation between number of cocoons, temperature and humidity. This interprets temperature and humidity play a major role in the production of yield of cocoons.

D. Visualization

In “Fig. 6”, the red line represents the slope and the blue dots represent the number of cocoons. The slope of the line indicates that, at a lower humidity percentage there are very less chances of obtaining maximum number of yield. As the humidity increases, a cluster of blue dots is observed, which infers that there is more possibility of getting the same yield throughout the year.

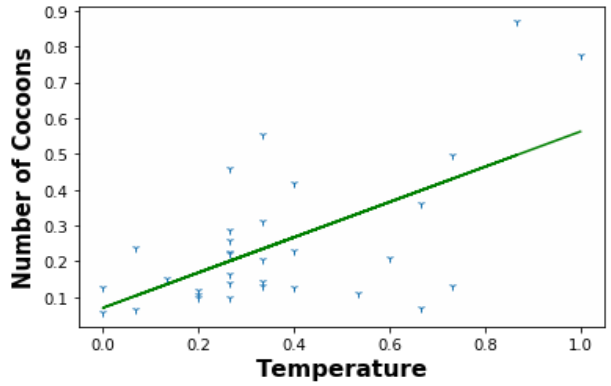
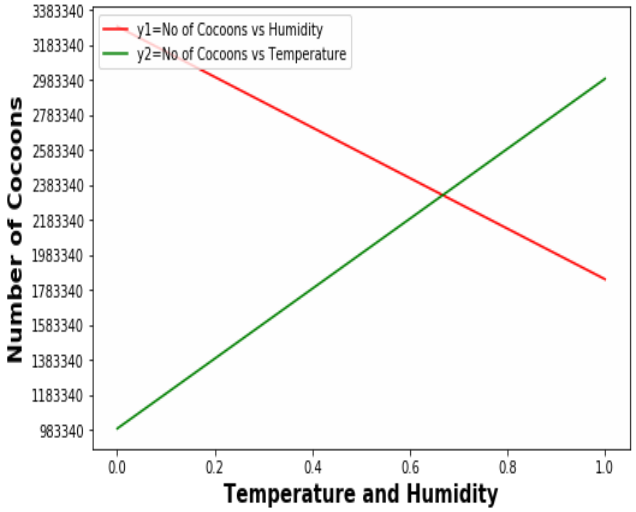


Fig. 7. Number of Cocoons versus Temperature

In “Fig. 7”, the green line represents the slope and the blue dots represent the number of cocoons. The slope of the line indicates that, at a lower temperature, a cluster of blue dots is observed, which infers that there is more possibility of getting the same yield throughout the year. As the temperature increases, there is fluctuation in the yield.



In “Fig. 8”, the slope of intersection point defines the optimum temperature (72-80 °F) and humidity (72-78%) that has to be maintained for obtaining the maximum yield of cocoons throughout the year.

IV. RESULT AND DISCUSSION

All the three graphs, ”Fig. 6”, “Fig. 7”, “Fig. 8” are plotted in the increasing order of number of cocoons with respect to number of batches received by the government every month. Applying the ‘DecisionTreeRegressor’, achieved 97% accuracy with respect to training set and 70% accuracy with respect to test set on the selected features.

V. CONCLUSION

Agricultural sector is one among the important sector for a country’s economic growth and its sustainability. Looking into the cottage industry foreign exchange, sericulture can also be made as a small scale industry (rearing the worms, producing the silk and marketing it) by many farmers. This paper provides a detailed description of the required methods and optimal climatic conditions needed for the rearing of silkworms at Attibele region of Karnataka. The study uses machine learning techniques to provide an accurate overview of the methodologies and steps to be undertaken by farmers to obtain the best yield of silk considering extreme climatic conditions along with remedies befitting farmlands without using chemical fertilizers. This conclusive study can help sustain and enhance the gradually declining silk industry and improve the economy in India.

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