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A case study on commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace (*Antheraea mylitta* Drury) in Kurjuli Forest area of Bandgaon Block, West Singhbhum district, Jharkhand, India

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Abstract

A case study was conducted on commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace (*Antheraea mylitta* Drury) to study the effect of age, education, experience and socio-economic conditions of the farmers on cocoon yield. Based on the rearing performance of 21361 dfls of Daba (Bi-Voltine) tasar ecorace distributed among 136 farmers, it was found that, 12 farmers produced more than 80 cocoons dfls⁻¹, which was the great achievement Indian tasar farming. Besides, 37 farmers have produced between 60-80 cocoons dfls⁻¹, 50 farmers produced 40-60 cocoons dfls⁻¹, 27 farmers produced 20-40 cocoons dfls⁻¹ and only 10 farmers have produced less than 20 cocoons dfls⁻¹ respectively. The rearing performance of 72.79 per cent farmers was better than the benchmark of 40-60 cocoons yield dfl⁻¹ adopted by the Indian tasar sericulturist. Based on the rearing performance of the farmers of different age group, it was found that, the maximum cocoons were produced by the farmers' age group of 30-40 and 40-50 years whereas the lowest cocoon production were recorded at the farmers below 30 years of age group. The highest cocoons yield dfl⁻¹ was recorded at the farmers below 30 years of age followed by lowest cocoons yield dfl⁻¹ at farmers above 60 years of age. While considering the education level, it was found that, the maximum cocoons were produced by the farmers having non-matric or 10+2 and above level of educational qualification followed by the illiterate farmers. The highest cocoon yield 70.77 cocoons dfl⁻¹ was produced by the educated farmers, who had matric or 10+2 level of educational qualification. The farmers experience has also shown the positive impact on cocoon yield.

Keywords: Sericulture, tasar, silkworm, daba (Bi-Voltine) tasar ecorace

Introduction

Sericulture is one of the oldest agro based cottage industry in India and probably dates back to the beginning of the Christian era. Scientifically, sericulture can be defined as "art and science of silkworm rearing" for the production of raw silk. The end product of sericulture is silk, which is well known as "Queen of fabrics" for its natural colour, purity and unusual lustre. Being an agro based cottage industry and intensive engagement of labour, sericulture is one of the major sectors for generation of rural and semi-urban employment. It is also an alternative source of income to enhance the livelihoods of small-scale farmers and tribal communities.

Geographically, Asia is the main producer and manufacturer of raw silk over worldwide. After China, India is the 2nd largest producer of raw silk with 0.354 Lakh MT annual productions against the total 1.596 Lakh MT world raw silk production in year 2018-19 (Anonymous, 2019; <https://www.inserco.org/en/statistics/>)^[1-2]. Brazil, Japan, Korea, Thailand, Uzbekistan and Vietnam etc. are also leading countries of raw silk production. On the global platform, sericulture industry has been divided into mulberry (*Bombyx mori* L.) and wild or Vanya silk. India is the only country which produces all the varieties of silk namely mulberry, eri, tropical tasar, oak tasar and muga etc. Out of these four varieties of silk in India, annual production of tasar raw silk (both tropical and oak tasar) was 2981 MT with 8.40 per cent share of total Indian raw silk production in 2018-19 (Anonymous, 2019^[1]).

Tropical tasar (*Antheraea mylitta* D.) is one of the strong pillars of sericulture industry and it plays a key role for empowerment of rural and tribal livelihood, regeneration of forest and best utility of low to marginal fertile land. Besides, this industry also generates the huge employment to the stake holders engaged in post cocoon. It is an eco-friendly forest-based cottage industry that requires a very low investment, but is highly remunerative and suits the tribal way of life with a positive impact on forest health and conservation of its biodiversity.

Tropical tasar silkworm (*Antheraea mylitta* Drury) is popularly known as wild or Vanya silkworm. These silkworms are polyphagous in nature and primarily fed on most popular trees Arjun (*Terminalia arjuna*), Asan (*Terminalia tomentosa*) and Sal (*Shorea robusta*) etc. (Gupta and Sinha, 2013) [3]. Besides, many other plants can also be feed as secondary food materials. Initially, the silkworm *Antheraea mylitta* D. was bred in the Europe during the beginning of 19th century and well distributed in the Asiatic continent (Srivastava *et al.*, 2003) [4]. In India, total 44 ecoraces of tropical tasar were identified and extensively reared in the tribal forest range of Orissa, Jharkhand, West Bengal, Madhya Pradesh, Chhattisgarh, Uttar Pradesh, Maharashtra, Telangana and Karnataka. (Alam *et al.*, 2018, Sharma *et al.*, 2015) [5-6]. Some of the most popular ecoraces of Indian terrain are Daba, Sukinda, Raily, Modal, Laria, Sarihan, Modia, Andhra Local etc.

Like mulberry silkworm, the life cycle of *A. mylitta* L. is also passes through four stages – egg, larva, pupa and adult. The larvae are voracious feeders while, adult are non-feeders. These ecoraces are morphogenetic variable in colour, shape and size etc. The eggs of tasar ecoraces are creamy, white, brownish or bluish in colour with 08-12 mm weight whereas the larval body of these ecoraces are either green, yellow, blue or almond in colour. The body weight of tasar silkworm larvae is highly variable and fully dependent on quality feeding and its genotypic characters. The body weight of 5th instar larvae is ranged from 18 to 52 g. The fifth instar larvae spin the cocoon and pupate inside. The cocoon of *A. mylitta* is tough with different shape and colour. The filament length of these silkworms ranged from 600 to 1500 m depending upon nature and varieties of ecoraces. The cocoon has a large peduncle, which terminates in a ring and fits into the branch of host plant. The races are univoltine, bivoltine and trivoltine in nature. Being a native of West Singhbhum district, Jharkhand, Daba Bv Tasar Ecorace (*A. mylitta* D.) was chosen for this study. Total 21361 disease free laying (DFLs) were distributed among the different age, education and experience groups of farmers for successful commercial crop rearing.

Materials and Methods

Location of the study area and Socio-economic condition of villagers

Location

The area selected for the case study on commercial silkworm

rearing of Daba (Bi-Voltine) Tasar Ecorace (*Antheraea mylitta* Drury) falls under Kaumail, Mundasai, Janko, Talasai, Dongosai, Puniburi, Tenda, Paprida, Indruwa, and Banragara tola of Bandgaon block, West Singhbhum, Jharkhand, India. These tolas are the small groups of the main villages namely; Kurjuli, Janko, Indruwa and Tendana. These main four villages lies between 22°39'33" N to 22°41'06" N latitude and 85°27'53" E to 85°29'51" E longitude with 300 to 500 altitude above MSL. The study area was situated in the dense forest of Kurjuli forest range, which is the part of Saranda dense forest of west singhbhum. Apart from shrubs and other tall trees, Kurjuli forest is mostly dominated by *Terminalia tomentosa* (Asan) and *Sorea robusta* (Sal) plants, which are the primary food materials of *A. mylitta* D.

According to Census, 2011 [7]; total 516 families were residing in these villages in a very small tolas scattered in Kurjuli forest area. These families were having total 2418 members including children with an average 4.68 members in a family. Out of total population, 1184 were male and 1234 female with average sex ratio 1042. In 2011, the literacy rate of male was 65.0 per cent and female was only 34.2 per cent with cumulative literacy rate 49.6 per cent. The literacy rate of the above villages was lower than the literacy rate of Jharkhand state which stands at 62.84 per cent. As per Census 2011, total 77.3 per cents workers from all four villages have less than 6 months employment as their main work and only 28.9 per cent have more than 6 months employment as their main work.

Selection of tasar farmers

Distribution of tasar farmers by Tola

Selection of tasar farmers was done based on their age, education, experience and socio-economic conditions. Total 136 farmers from Kaumail, Mundasai, Janko, Talasai, Dongosai, Puniburi, Tenda, Paprida, Indruwa, and Banragara tola/ village of Bandgaon block, West Singhbhum, Jharkhand were selected under adopted seed rearers (ASR) programme for commercial or 2nd seed crop rearing for the financial year 2019-20. These tolas are the small busty of Kurjuli, Janko, Indruwa and Tendana village of same block and district. All the farmers selected under this programme were mostly landless or marginal farmers of scheduled tribe category. They are mostly very poor and living their life under below poverty line. Tola wise list of tasar farmers under ASR programme are given in Fig. 1.

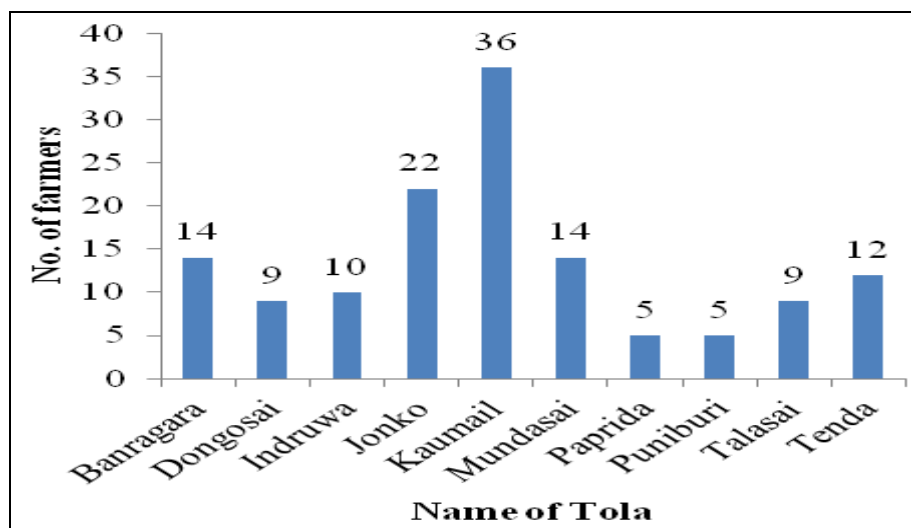


Fig 1: Tola wise list of tasar farmers under ASR programme

Distribution of farmers based on their age and education

As the area selected for commercial rearing was backward with lack of basic educational facilities. There were no higher educational institutes available nearby their villages; hence,

most of the farmers were either illiterate or non-metric level. Distribution of farmers by their age and education are given in Table 1 and Fig. 2.

Table 1: Distribution of farmers by Age and Education

| Age group | Educational level | | | | Total |
|--------------|-------------------|---------|------------|----------------------------|--------|
| | Illiterate | Primary | Non-Matric | 10 th and above | |
| Below 30 | 0 | 8 | 3 | 3 | 14 |
| | 0.0% | 57.1% | 21.4% | 21.4% | 100.0% |
| 30-40 | 2 | 17 | 12 | 4 | 35 |
| | 5.7% | 48.6% | 34.3% | 11.4% | 100.0% |
| 40-50 | 9 | 14 | 13 | 1 | 37 |
| | 24.3% | 37.8% | 35.1% | 2.7% | 100.0% |
| 50-60 | 10 | 18 | 3 | 1 | 32 |
| | 31.3% | 56.3% | 9.4% | 3.1% | 100.0% |
| 60 and above | 11 | 6 | 1 | 0 | 18 |
| | 61.1% | 33.3% | 5.6% | 0.0% | 100.0% |
| Total | 32 | 63 | 32 | 9 | 136 |
| | 23.5% | 46.3% | 23.5% | 6.6% | 100.0% |

Pearson Ch-square Test : 39.51**

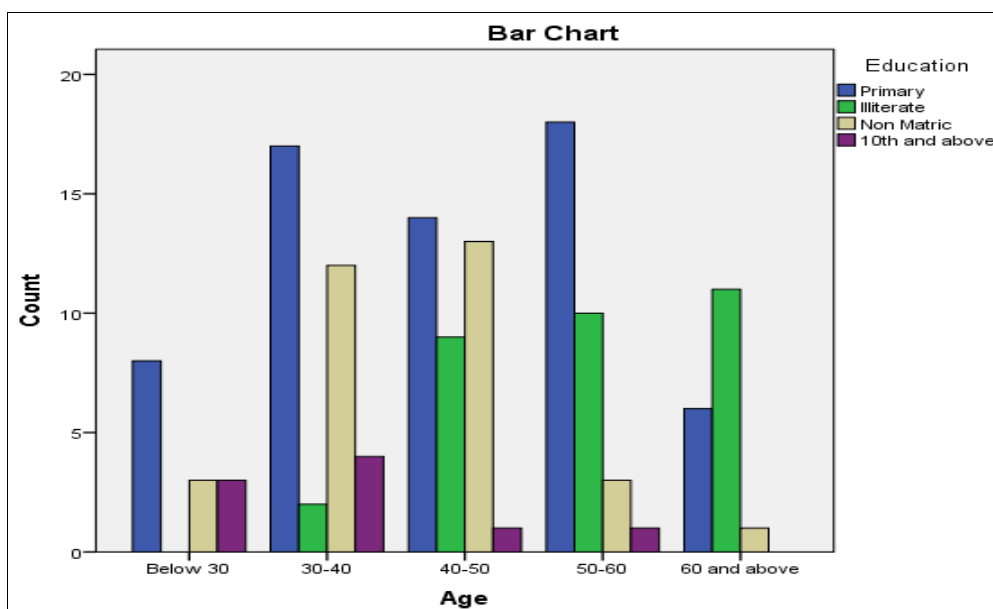


Fig 2: Distribution of farmers by Age and Educational level

Distribution of farmers by age and occupation

The basic occupation of the farmers selected under this programme was agriculture. These farmers were having either very less or marginal land holdings and fully dependent on agriculture and allied sectors for their livelihood. Some of the farmers were also practicing tasar sericulture before 10-15 years back and they were left sericulture by their own choice

to adopt other occupation for their livelihood. Farmers involved under programme were also a seasonal labourer based on the availability of works, but, under this programme these farmers were grouped under agriculture. Distribution of farmers by age and occupation are given in Table 2 and Fig. 3.

Table 2: Distribution of farmers by Age and Occupation

| Age group | Occupation | | | | | Total |
|--------------|-------------|--------|-------------|----------|-------------|--------|
| | Agriculture | Labour | Private job | Business | Sericulture | |
| Below 30 | 13 | 0 | 0 | 1 | 0 | 14 |
| | 92.9% | 0.0% | 0.0% | 7.1% | 0.0% | 100.0% |
| 30-40 | 31 | 2 | 0 | 2 | 0 | 35 |
| | 88.6% | 5.7% | 0.0% | 5.7% | 0.0% | 100.0% |
| 40-50 | 35 | 0 | 0 | 1 | 1 | 37 |
| | 94.6% | 0.0% | 0.0% | 2.7% | 2.7% | 100.0% |
| 50-60 | 31 | 0 | 1 | 0 | 0 | 32 |
| | 96.9% | 0.0% | 3.1% | 0.0% | 0.0% | 100.0% |
| 60 and above | 18 | 0 | 0 | 0 | 0 | 18 |
| | 100.0% | 0.0% | 0.0% | 0.0% | 0.0% | 100.0% |

| | | | | | | |
|--|-------|------|-----|------|-----|--------|
| Total | 128 | 2 | 1 | 4 | 1 | 136 |
| | 94.1% | 1.5% | .7% | 2.9% | .7% | 100.0% |
| Pearson Ch-square Test : 15.14 ^{NS} | | | | | | |

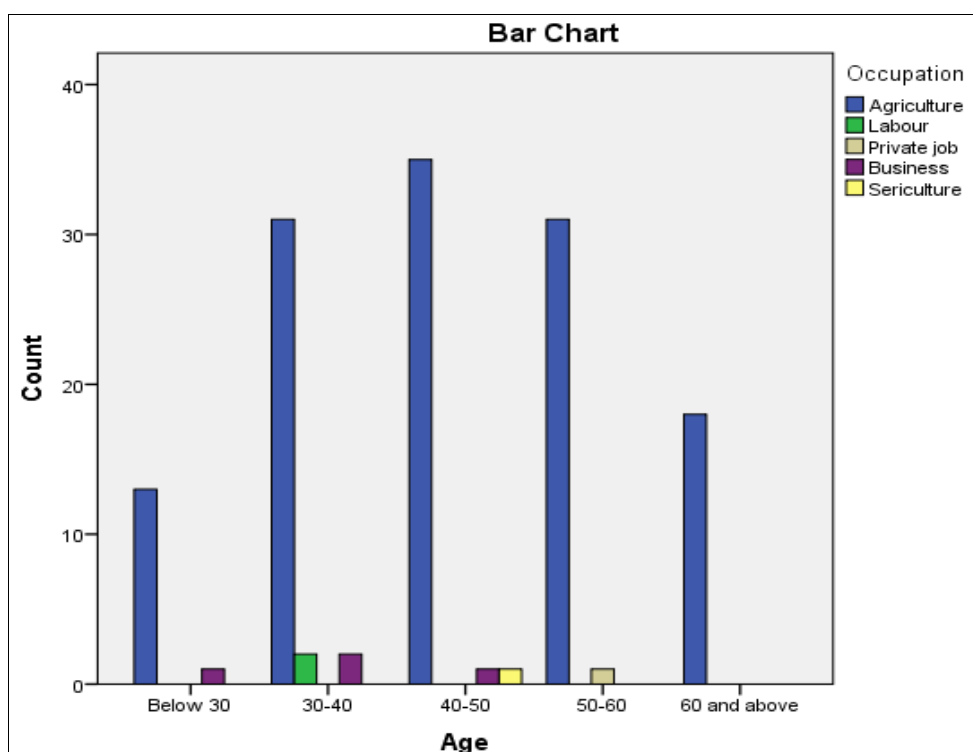


Fig 3: Distribution of farmers by age and occupation

Distribution of farmers by age and experience in tasar culture

The farmers selected under this programme were ranged from least to well expertise in tasar sericulture.

For this purpose, farmers were grouped into five different groups i.e. 0-3 years, 4-6 years, 7-9 years, 10-12 years and 13 and above years experience in tasar farming. Based on the experience of farmers, 36 farmers were either new or they were having maximum three years of experience in tasar farming. Besides, 34 farmers were having 4-6 years

experience, 11 farmers were having 7-9 years experience, 47 farmers were having 10-12 years experience and only 8 farmers were having 13 years or more experience in tasar farming.

Distribution of farmers by total income and age

The farmers selected under this programme were very poor and living their life under below poverty line. Distribution of farmers by total income and age are given in Table 3 and Fig. 4.

Table 3: Distribution of farmers by total income and age

| Total Income group | Age | | | | | Total |
|--|----------|--------|-------|-------|--------------|--------|
| | Below 30 | 30-40 | 40-50 | 50-60 | 60 and above | |
| Below 20,000 | 0 | 1 | 0 | 0 | 0 | 1 |
| | 0.0% | 100.0% | 0.0% | 0.0% | 0.0% | 100.0% |
| 20,000 - 40,000 | 6 | 7 | 4 | 3 | 1 | 21 |
| | 28.6% | 33.3% | 19.0% | 14.3% | 4.8% | 100.0% |
| 40,000 - 60,000 | 4 | 16 | 21 | 19 | 9 | 69 |
| | 5.8% | 23.2% | 30.4% | 27.5% | 13.0% | 100.0% |
| 60,000 - 80,000 | 3 | 6 | 6 | 3 | 5 | 23 |
| | 13.0% | 26.1% | 26.1% | 13.0% | 21.7% | 100.0% |
| 80,000 and Above | 1 | 5 | 6 | 7 | 3 | 22 |
| | 4.5% | 22.7% | 27.3% | 31.8% | 13.6% | 100.0% |
| Total | 14 | 35 | 37 | 32 | 18 | 136 |
| | 10.3% | 25.7% | 27.2% | 23.5% | 13.2% | 100.0% |
| Pearson Ch-square Test : 18.80 ^{NS} | | | | | | |

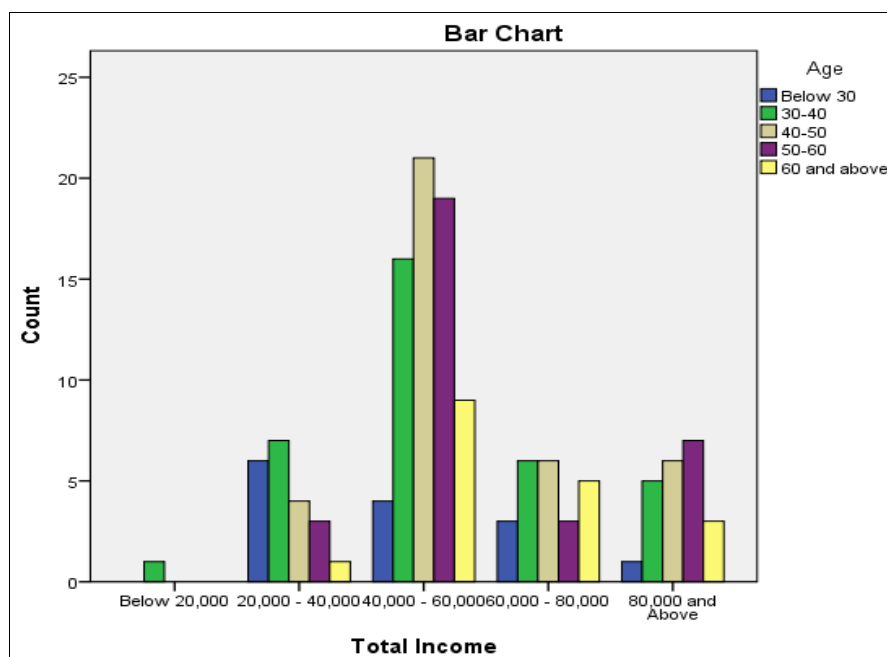


Fig 4: Distribution of farmers by total income and Age group

Results and Discussions

Performance of commercial silkworm rearing of Daba (Bi-Voltine) based on cocoon yield

Based on the rearing performance of 21361 dfls of Daba (Bi-Voltine) tasar ecorace distributed among 136 tasar farmers for commercial silkworm rearing, 2019 in Kurjuli forest area, West Singhbhum district, Jharkhand, India, it was found that, 12 farmers produced more than 80 cocoons dfls⁻¹, which was the great achievement Indian tasar farming. Besides, 37 farmers have produced between 60-80 cocoons dfls⁻¹, 50 farmers produced 40-60 cocoons dfls⁻¹, 27 farmers produced 20-40 cocoons dfls⁻¹ and only 10 farmers have produced less than 20 cocoons dfls⁻¹ respectively. The rearing performance of 72.79 per cent farmers was better than the benchmark of 40-60 cocoons yield dfl⁻¹ adopted by the Indian tasar sericulturist. The hatching per cent of the dfls distributed for commercial silkworm rearing and total larval period among the entire farmers field was almost similar. Likewise, the

weight of 5th instars larvae was also similar with slight variation. The single cocoon weight (g), single shell weight (g) and shell ratio (%) was also higher with the high cocoon yield. In surprising way, it was found that, the collectively total Rs. 32.98 lakhs were earned by the farmers in a single crop. The income of the individual farmer was variable based the quantity of dfls reared by them and production of total cocoons, however, the mean value of total income of a single farmer was Rs. 0.24 lakh. Likewise, the farmer's wise total income per dfl was also variable with a value of Rs. 154.39 per dfl. The single cocoon weight (g), single shell weight (g) and shell ratio (%) was highly correlates with the total cocoon yield per dfl. The Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on cocoon yield are given in Table 4 and Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on cocoon yield are given in Table 5.

Table 4: Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on cocoon yield

| S. No. | Characteristics | Below 20 cocoons yield dfl ⁻¹ | 20-40 cocoons yield dfl ⁻¹ | 40-60 cocoons yield dfl ⁻¹ | 60-80 cocoons yield dfl ⁻¹ | Above 80 cocoons yield dfl ⁻¹ | Total/ Mean |
|--------|--|--|---------------------------------------|---------------------------------------|---------------------------------------|--|-------------|
| 1. | No. of farmers covered | 10 | 27 | 50 | 37 | 12 | 136 |
| 2. | No. of dfls brushed | 1950 | 3850 | 7650 | 6161 | 1750 | 21361 |
| 3. | Hatching (%) | 86.80 | 85.26 | 85.24 | 84.50 | 85.50 | 85.46 |
| 4. | Larval duration (days) | 41 | 41 | 41 | 41 | 42 | 41.2 |
| 5. | Weight of 5 th instars larvae (g) | 40.2 | 40.19 | 40.56 | 40.69 | 42 | 40.73 |
| 6. | Total Cocoon Harvested (in Lakhs) | 0.29 | 1.3 | 3.78 | 4.39 | 1.52 | 11.28 |
| 7. | Cocoons yield dfl ⁻¹ | 14.87 | 33.77 | 49.41 | 71.25 | 86.86 | 52.81 |
| 8. | Highest cocoons yield of single farmer dfl ⁻¹ | 19.33 | 39.95 | 59 | 79.83 | 101.5 | 59.92 |
| 9. | Single Cocoon Weight (g) | 13.17 | 12.99 | 13.2 | 13.41 | 13.75 | 13.3 |
| 10. | Single Shell Weight (g) | 1.63 | 1.67 | 1.75 | 1.84 | 1.96 | 1.77 |
| 11. | Shell Ratio (%) | 12.37 | 12.85 | 13.25 | 13.72 | 14.25 | 13.31 |
| 12. | Total income of farmers from Tasar (in Lakh) | 0.80 | 3.82 | 10.65 | 12.89 | 4.82 | 32.98 |
| 13. | Highest income of single farmer (in Lakh) | 0.11 | 0.29 | 0.42 | 0.96 | 0.86 | 0.53 |
| 14. | Average income of single farmer (in Lakh) | 0.08 | 0.14 | 0.21 | 0.35 | 0.40 | 0.24 |
| 15. | Total income dfl ⁻¹ (Rs.) | 41.03 | 99.22 | 139.22 | 209.22 | 275.43 | 154.39 |

Table 5: Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on cocoon yield

| # | No. of farmers covered | No. of dfls brushed | Total Cocoon Harvested | Cocoons yield dfl ⁻¹ | Single Cocoon Weight | Single Shell Weight | Shell Ratio (%) | Total income of farmers from Tasar |
|------------------------------------|------------------------|---------------------|------------------------|---------------------------------|----------------------|---------------------|-----------------|------------------------------------|
| No. of farmers covered | 1 | .992** | 0.854 | 0.125 | -0.292 | -0.026 | 0.093 | 0.83 |
| No. of dfls brushed | | 1 | .883* | 0.113 | -0.276 | -0.034 | 0.076 | 0.859 |
| Total Cocoon Harvested | | | 1 | 0.508 | 0.149 | 0.376 | 0.465 | .999** |
| Cocoons yield dfl ⁻¹ | | | | 1 | 0.856 | .983** | .998** | 0.546 |
| Single Cocoon Weight | | | | | 1 | .933* | 0.868 | 0.189 |
| Single Shell Weight | | | | | | 1 | .989** | 0.416 |
| Shell Ratio (%) | | | | | | | 1 | 0.503 |
| Total income of farmers from Tasar | | | | | | | | 1 |

The variation in cocoon yield dfl⁻¹ of commercial crop rearing in Kurjuli forest was due to lack of quality leaves of tasar food plants, management practices, age and education level of farmers and topography etc. Apart from quality leaves of tasar food plants, most of the constraints responsible of declining cocoon yield have been discussed separately. As it is well known fact that, the life of an insect is significantly depends on balanced nutrition (Beck 1956; Waldbauer, 1968; Hassell and Southwood, 1978 and Rath, 2005) [8-11]. In tasar silkworm, leaves of most popular trees Arjun (*Terminalia arjuna*), Asan (*Terminalia tomentosa*) and Sal (*Shorea robusta*) are primary food material (Gupta and Sinha, 2013) [3] and the quality of good tasar cocoon depends on nutritive value of their food plants (Sahay *et al.*, 2001 and Singhvi, 2014) [12-13].

Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on farmer's age group

The performance of commercial silkworm rearing of 21361 dfls of Daba (Bi-Voltine) tasar ecorace among 136 tasar farmers level were also analyzed based on their different age group. For this purpose, farmers were grouped into five different age groups i.e. 1. Farmers age below 30 years, 2. Farmers age from 30 to 40 years, 3. Farmers age from 40 to 50 years, 4. Farmers age from 50 to 60 years and 5. Farmers age from 60 years and above respectively. Based on the grouping of farmers under different age groups stated above, 14 farmers were grouped under below 30 years of age, 35 farmers were grouped between 30 to 40 years of age, 37 farmers were grouped between 40 to 50 years of age, 32 farmers were grouped between 50 to 60 years of age and only 18 farmers were grouped above 60 years age. Likewise, total

2050 dfls were distributed among the farmers of below 30 years group, 5601 dfls were distributed among the farmers between 30 to 40 years group, 5550 dfls were distributed among the farmers between 40 to 50 years group, 5210 dfls were distributed among the farmers between 50 to 60 years group and only 2950 dfls were distributed among the farmers of above 60 years age group.

Based on the rearing performance of the farmers of different age group, it was found that, the maximum cocoons were produced by the farmers' age group of 30-40 and 40-50 years whereas the lowest cocoon production were recorded at the farmers below 30 years of age group. Unlike, highest cocoons yield dfl⁻¹ was recorded at the farmers below 30 years of age followed by lowest cocoons yield dfl⁻¹ at farmers above 60 years of age. The hatching per cent of the dfls distributed for commercial silkworm rearing and total larval period among the entire farmers field was almost similar. Likewise, the weight of 5th instars larvae was also similar with slight variation. The single cocoon weight (g), single shell weight (g) and shell ratio (%) was also higher with the high cocoon yield dfl⁻¹. The income of the individual farmer was variable based the quantity of dfls reared by them and production of total cocoons. Maximum income was generated by the middle age group of farmers. The farmer's wise total income dfl⁻¹ was also variable. The single cocoon weight (g), single shell weight (g) and shell ratio (%) was highly correlates with the total cocoon yield per dfl. The performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on farmer's age group are given in Table 6 and Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on based on farmer's age group are given in Table 7.

Table 6: Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on farmer's age group

| S. No. | Characteristics | Farmers age below 30 years | Farmers age 30-40 years | Farmers age 40-50 years | Farmers age 50-60 years | Farmers age from 60 years & above | Total/ Mean |
|--------|--|----------------------------|-------------------------|-------------------------|-------------------------|-----------------------------------|-------------|
| 1. | No. of farmers covered | 14 | 35 | 37 | 32 | 18 | 136 |
| 2. | No. of dfls brushed | 2050 | 5601 | 5550 | 5210 | 2950 | 21361 |
| 3. | Hatching (%) | 86.14 | 85.14 | 84.86 | 85.44 | 84.78 | 85.46 |
| 4. | Larval duration (days) | 42 | 41 | 41 | 41 | 41 | 41.20 |
| 5. | Weight of 5 th instars larvae (g) | 41.14 | 40.34 | 40.56 | 40.88 | 40.72 | 40.73 |
| 6. | Total Cocoon Harvested (in Lakhs) | 1.07 | 2.82 | 3.17 | 2.68 | 1.54 | 11.28 |
| 7. | Cocoons yield dfl ⁻¹ | 52.20 | 50.35 | 57.12 | 51.44 | 52.20 | 52.81 |
| 8. | Highest cocoons yield of single farmer dfl ⁻¹ | 101.50 | 96.00 | 91.50 | 92.80 | 79.50 | 92.26 |
| 9. | Single Cocoon Weight (g) | 13.18 | 13.59 | 13.24 | 13.20 | 13.31 | 13.26 |
| 10. | Single Shell Weight (g) | 1.72 | 1.79 | 1.76 | 1.75 | 1.78 | 1.76 |
| 11. | Shell Ratio (%) | 13.05 | 13.54 | 13.29 | 13.26 | 13.37 | 13.31 |
| 12. | Total income of farmers from Tasar (in Lakh) | 2.79 | 8.65 | 9.58 | 7.62 | 4.34 | 32.98 |
| 13. | Highest income of single farmer (in Lakh) | 0.44 | 0.96 | 0.86 | 0.70 | 0.48 | 0.69 |
| 14. | Average income of single farmer (in Lakh) | 0.20 | 0.25 | 0.26 | 0.24 | 0.24 | 0.24 |
| 15. | Total income dfl ⁻¹ (Rs.) | 136.10 | 154.44 | 172.61 | 146.26 | 147.12 | 154.39 |

Table 7: Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on farmer's age group

| # | No. of farmers covered | No. of dfls brushed | Total Cocoon Harvested | Cocoons yield dfl ⁻¹ | Single Cocoon Weight | Single Shell Weight | Shell Ratio (%) | Total income of farmers from Tasar |
|------------------------------------|------------------------|---------------------|------------------------|---------------------------------|----------------------|---------------------|-----------------|------------------------------------|
| No. of farmers covered | 1 | .993** | .996** | -0.568 | 0.269 | 0.462 | 0.566 | .996** |
| No. of dfls brushed | | 1 | .988** | -0.658 | 0.312 | 0.512 | 0.618 | .985** |
| Total Cocoon Harvested | | | 1 | -0.553 | 0.253 | 0.464 | 0.582 | .997** |
| Cocoons yield dfl ⁻¹ | | | | 1 | -0.317 | -0.507 | -0.603 | -0.527 |
| Single Cocoon Weight | | | | | 1 | .947* | 0.839 | 0.305 |
| Single Shell Weight | | | | | | 1 | .970** | 0.499 |
| Shell Ratio (%) | | | | | | | 1 | 0.602 |
| Total income of farmers from Tasar | | | | | | | | 1 |

While studying on the barriers affecting sustainable agricultural productivity of small farm holders in South Africa, Myeni *et al.*, (2019) [14] reported that, most of the younger generation does not show their interest towards farming, though, the rate of unemployment is higher. There are several studies, which show that, the youth have more ability to adopt the sustainable or improved practices than aged farmers. Kabi and Horwitz (2006) [15] reported that, the aged farmers involved in agriculture are less likely to adopt new sustainable practices and often rely on their indigenous knowledge to manage their farms. Baumgart *et al.*, (2012) [16] also reported the similar findings. Ndiritu *et al.*, (2014) [17] opined that, the indigenous knowledge of old farmers, now a day is not much effective due to climate change and variability, hence, integration of indigenous knowledge and scientific agricultural management practices seems to be a key for sustainable agricultural productivity of smallholder farmers (Thamaga, 2012) [18].

Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their educational qualification

The performance of commercial silkworm rearing of 21361 dfls of Daba (Bi-Voltine) tasar ecorace among 136 tasar farmers level were analyzed based on their educational qualification. For this purpose, farmers were grouped into four different educational qualification groups i.e. illiterate, primary, non-matric and matric and above respectively. Based on the grouping of farmers under different educational qualification stated above, 33 farmers were illiterate, 62 farmers were educated at primary level, 32 farmers were non-matric and only 9 farmers were having matric or 10+2 level educational qualification. Hence, about 70 per cent farmers covered under this study was either illiterate or they were just literate and having only primary level of education and only 6.6 per cent farmers were educated at matric or 10+2 level. Based on the educational qualifications of the farmers, total

4950 dfls were brushed by the illiterate farmers, 9310 dfls were brushed by the farmers having primary level educational qualification, 5801 dfls were brushed by the farmers having non-matric level educational qualification and only 1300 dfls were brushed by the farmers having matric or 10+2 level educational qualification.

Based on the rearing performance of the farmers of different education level, it was found that, the maximum cocoons were produced by the farmers having non-matric or matric and above level of educational qualification whereas the lowest cocoon production were recorded by the illiterate farmers. The impact of education was adversely affects the cocoon yield. Though, the farmers having upto primary level of education came forward for tasar farming and reared more dfls than other educated farmers, but, their performance in terms of total cocoon yield was lower than the qualified farmers. The highest cocoon yield 70.77 cocoons dfl⁻¹ was produced by the educated farmers, who had matric or 10+2 level of educational qualification followed by 59.30 cocoons dfl⁻¹ produced by the non-matric level educated farmers. The lowest cocoon yield 47.26 dfl⁻¹ was produced by the primary level educated farmers. The single cocoon weight (g), single shell weight (g) and shell ratio (%) was also higher with the high cocoon yield dfl⁻¹. The income of the individual farmer was variable based the quantity of dfls reared by them and production of total cocoons. Maximum gross income was generated by the illiterate or primary level educated farmers, whereas, the maximum single farmers income was generated by the educated farmers. The farmer's wise total income dfl⁻¹ was also higher at educated farmers' field. The single cocoon weight (g), single shell weight (g) and shell ratio (%) was highly correlates with the total cocoon yield per dfl. The performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their educational qualification are given in Table 8 and Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their educational qualification are given in Table 9.

Table 8: Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their educational qualification

| Sl. No. | Characteristics | Illiterate | Primary | Non-Matric | Matric & above | Total/ Mean |
|---------|--|------------|---------|------------|----------------|-------------|
| 1. | No. of farmers covered | 33 | 62 | 32 | 9 | 136 |
| 2. | No. of dfls brushed | 4950 | 9310 | 5801 | 1300 | 21361 |
| 3. | Hatching (%) | 85.37 | 85.48 | 85.19 | 85.80 | 85.46 |
| 4. | Larval duration (days) | 41.21 | 41.08 | 41.47 | 41.04 | 41.20 |
| 5. | Weight of 5 th instars larvae (g) | 40.61 | 40.58 | 40.87 | 40.86 | 40.73 |
| 6. | Total Cocoon Harvested (in Lakhs) | 2.52 | 4.40 | 3.44 | 0.92 | 11.28 |
| 7. | Cocoons yield dfl ⁻¹ | 50.91 | 47.26 | 59.30 | 70.77 | 52.81 |
| 8. | Highest cocoons yield of single farmer dfl ⁻¹ | 91.50 | 96.00 | 86.00 | 101.50 | 93.75 |
| 9. | Single Cocoon Weight (g) | 13.25 | 13.19 | 13.39 | 13.37 | 13.30 |
| 10. | Single Shell Weight (g) | 1.69 | 1.74 | 1.82 | 1.83 | 1.77 |
| 11. | Shell Ratio (%) | 12.75 | 13.20 | 13.59 | 13.69 | 13.31 |
| 12. | Total income of farmers from Tasar (in Lakh) | 7.17 | 12.48 | 10.29 | 3.04 | 32.98 |
| 13. | Highest income of single farmer (in Lakh) | 0.48 | 0.70 | 0.96 | 0.78 | 0.73 |
| 14. | Average income of single farmer (in Lakh) | 0.22 | 0.20 | 0.32 | 0.34 | 0.27 |
| 15. | Total income dfl ⁻¹ (Rs.) | 144.85 | 134.05 | 177.38 | 233.85 | 154.39 |

Table 9: Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their educational qualification

| # | No. of farmers covered | No. of dfls brushed | Total Cocoon Harvested | Cocoons yield dfl ⁻¹ | Single Cocoon Weight | Single Shell Weight | Shell Ratio (%) | Total income of farmers from Tasar |
|------------------------------------|------------------------|---------------------|------------------------|---------------------------------|----------------------|---------------------|-----------------|------------------------------------|
| No. of farmers covered | 1 | .988* | 0.941 | -0.866 | -0.794 | -0.868 | -0.864 | 0.92 |
| No. of dfls brushed | | 1 | .982* | -0.861 | -0.696 | -0.791 | -0.79 | .970* |
| Total Cocoon Harvested | | | 1 | -0.825 | -0.552 | -0.671 | -0.673 | .998** |
| Cocoons yield dfl ⁻¹ | | | | 1 | 0.769 | 0.863 | 0.88 | -0.797 |
| Single Cocoon Weight | | | | | 1 | .986* | .980* | -0.502 |
| Single Shell Weight | | | | | | 1 | .999** | -0.625 |
| Shell Ratio (%) | | | | | | | 1 | -0.627 |
| Total income of farmers from Tasar | | | | | | | | 1 |

Studying the effect of education level to enhance the productivity of agricultural farmers with small farm holdings in Malawi, South Africa, Ferreira (2018) [19] concluded that, the educated farmers with modern technology recorded higher productivity than others. Based on the 37 datasets on farmers education and their productivity in 13 developing countries, Lockheed *et al.* (1980; 1987) [20-21] concluded that, the agricultural productivity significantly increases at 4 years educated farmers field, when, compared with zero years education. They also found that the effects of education were much higher when farmers used modern technologies. Phillips (1987, 1994) [22-23] also reported the similar findings with large regional variations.

While studying the effect of education level on rice production in Bangladesh, Asadullah and Rahman (2009) [24] found the positive effects for the household head's education, but after adding in the highest education level in the household, the effect of the head's education became statistically insignificant while the effect of the highest level of education became significant. Appleton and Balihuta (1996) [25] estimated the returns to education for farmers in Uganda using production functions and found positive results. Weir (1999) [26] and Alene and Manyong (2007) [27] also reported the similar finding on cereal production. They found more significant results with improved technology at educated farmers' field. Various scientists across the world have also reported the significant effect of farmers' education on agricultural produce with or without adopting of modern technologies. They found more significant effect at educated farmers with modern technologies (Jamison and Moock 1984;

Foster and Rosenzweig 2004 and Davis *et al.* 2010) [28-30].

Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their experience in tasar farming

The performance of commercial silkworm rearing of 21361 dfls of Daba (Bi-Voltine) tasar ecorace among 136 tasar farmers level were analyzed based on their experience in tasar farming. For this purpose, farmers were grouped into five different groups i.e. 0-3 years, 4-6 years, 7-9 years, 10-12 years and 13 and above years experience in tasar farming. Based on the experience of farmers, 36 farmers were either new or they were having maximum three years of experience in tasar farming and rest of the farmers were well experienced and actively involved in tasar farming. Some of the well experience farmers were discontinued the tasar farming few years back and migrated into another job for better livelihood. These types of farmers were also convinced by the official and involved into this rearing. Based on the experience of the farmers, total 4836 dfls were brushed by the new farmers, 4950 dfls were brushed by the 4-6 years experienced farmers, 1700 dfls were brushed by the 7-9 years experienced farmers, 8675 dfls were brushed by the 10-12 years experienced farmers and only 1200 dfls were brushed by the 13 years and above experienced farmers. Maximum gross income was also generated by the experienced farmers by highest cocoon dfl⁻¹. The performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their experience in tasar farming is given in Table 10 and its Pearson correlation is given in Table 11.

Table 10: Performance of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their experience in tasar farming

| Sl. No. | Characteristics | 0-3 years experience | 4-6 years experience | 7-9 years experience | 10-12 years experience | 13 years & above experience | Total/ Mean |
|---------|--|----------------------|----------------------|----------------------|------------------------|-----------------------------|-------------|
| 1. | No. of farmers covered | 36 | 34 | 11 | 47 | 8 | 136 |
| 2. | No. of dfls brushed | 4836 | 4950 | 1700 | 8675 | 1200 | 21361 |
| 3. | Hatching (%) | 84.44 | 85.82 | 86.00 | 85.79 | 85.25 | 85.46 |
| 4. | Larval duration (days) | 41.03 | 41.03 | 41.18 | 41.79 | 40.97 | 41.20 |
| 5. | Weight of 5 th instars larvae (g) | 40.63 | 40.51 | 40.69 | 40.93 | 40.88 | 40.73 |
| 6. | Total Cocoon Harvested (in Lakhs) | 2.26 | 2.29 | 0.91 | 5.04 | 0.78 | 11.28 |
| 7. | Cocoons yield dfl ⁻¹ | 46.73 | 46.26 | 53.53 | 58.10 | 65.00 | 52.81 |
| 8. | Highest cocoons yield of single farmer dfl ⁻¹ | 89.20 | 74.55 | 81.13 | 101.50 | 79.50 | 85.18 |
| 9. | Single Cocoon Weight (g) | 13.32 | 13.07 | 13.12 | 13.31 | 13.71 | 13.30 |
| 10. | Single Shell Weight (g) | 1.70 | 1.73 | 1.72 | 1.80 | 1.91 | 1.77 |
| 11. | Shell Ratio (%) | 12.76 | 13.24 | 13.11 | 13.52 | 13.93 | 13.31 |
| 12. | Total income of farmers from Tasar (in Lakh) | 6.42 | 6.49 | 3.32 | 14.44 | 2.31 | 32.98 |
| 13. | Highest income of single farmer (in Lakh) | 0.44 | 0.37 | 0.86 | 0.96 | 0.48 | 0.62 |
| 14. | Average income of single farmer (in Lakh) | 0.18 | 0.19 | 0.30 | 0.31 | 0.29 | 0.25 |
| 15. | Total income dfl ⁻¹ (Rs.) | 132.75 | 131.11 | 195.29 | 166.46 | 192.50 | 154.39 |

Table 11: Pearson correlation of commercial silkworm rearing of Daba (Bi-Voltine) tasar ecorace based on their experience in tasar farming

| # | No. of farmers covered | No. of dfls brushed | Total Cocoon Harvested | Cocoons yield dfl ⁻¹ | Single Cocoon Weight | Single Shell Weight | Shell Ratio (%) | Total income of farmers from Tasar |
|------------------------------------|------------------------|---------------------|------------------------|---------------------------------|----------------------|---------------------|-----------------|------------------------------------|
| No. of farmers covered | 1 | .969** | .909* | -0.431 | -0.36 | -0.328 | -0.287 | .895* |
| No. of dfls brushed | | 1 | .983** | -0.278 | -0.296 | -0.222 | -0.151 | .977** |
| Total Cocoon Harvested | | | 1 | -0.133 | -0.199 | -0.107 | -0.027 | .998** |
| Cocoons yield dfl ⁻¹ | | | | 1 | .911* | .965** | .960** | -0.14 |
| Single Cocoon Weight | | | | | 1 | .957* | .881* | -0.223 |
| Single Shell Weight | | | | | | 1 | .980** | -0.13 |
| Shell Ratio (%) | | | | | | | 1 | -0.047 |
| Total income of farmers from Tasar | | | | | | | | 1 |

Conclusion

Based on the rearing performance of 21361 dfls of Daba (Bi-Voltine) tasar ecorace distributed among 136 farmers, it can be concluded that, the rearing performance of 72.79 per cent farmers was better than the benchmark of 40-60 cocoons yield dfl⁻¹ adopted by the Indian tasar sericulturist. Besides, Age, education and experience have also correlation with silkworm rearing which ultimately affects the cocoon yield.

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