INFLUENCE OF S_{36} MULBERRY VARIETY ON THE REARING PERFORMANCE OF THE SILKWORM *Bombyx mori*. L.

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Affectionately dedicated to

My beloved Parents

Smt. Chandramma and Sri. S. Nanjaiah

DEPARTMENT OF SERICULTURE
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE

CERTIFICATE

This is to certify that the thesis entitled "**INFLUENCE OF S_{36} MULBERRY VARIETY ON THE REARING PERFORMANCE OF SILKWORM**" ***Bombyx mori*, L.** submitted by **Mr. Venugopal, S.N.** for the degree of **MASTER OF SCIENCES** (Sericulture) of the university of Agricultural Sciences, Bangalore is a record of Research work done by him during the period of study in this University under my guidance and supervision and the Thesis has not previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles.

Bangalore

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INTRODUCTION

I INTRODUCTION

Sericulture is a highly labour intensive, remunerative and rural welfare oriented agrobased industry. In the global context, India with the production of 15,214 metric tonnes during 2000-2001, is the second largest silk producing country next to China. Mulberry raw silk production in India is mainly confined to the states of Karnataka, Andhrapradesh, West Bengal, Tamilnadu and Jammu and Kashmir, jointly accounting for 99 per cent of the country's total mulberry raw silk production. However, Karnataka occupies a prominent place in the sericulture map, by producing 65.75 per cent of Indian mulberry raw silk production (Sharma, 2001).

Silk is a natural fibre secreted by silkworms for the protection of pupae, in the process of completing their life cycle. The process of feeding the silkworm with mulberry leaf makes it to spin cocoon when reeled it gives silk filament. Growing of mulberry plant for quality leaf to feed the silkworm is the first and foremost pre-requisite for successful sericulture.

Mulberry is grown both under rainfed and irrigated condition. In the VIII five year plan a target of 3.0 lakh hectares under irrigated mulberry and 1.25 lakh hectares under rainfed mulberry has been envisaged (Anon., 1992).

Mulberry is the sole food plant for the silkworm *Bombyx mori* L., the fresh and nutritive quality of mulberry leaf plays an important role on the development of worms and stabilizing the cocoon production and silk productivity. The various factors responsible for successful cocoon harvest and silk productivity are mulberry leaf (38.2%), climate (37.0%), rearing technique (9.3%), silkworm breed (4.2%), silkworm egg (3.1%) and other factors (6.6%) (Miyashita, 1986). Thus mulberry leaf quality plays a dominant role in healthy growth of silkworm and maximization of cocoon production.

The quality of feed is determined by it's major components such as water, carbohydrates, proteins, mineral elements, fats, amino acids and vitamins (Rangaswamy *et al.*, 1976).

The S_{36} variety was evolved by the CSR and TI, Mysore. and released only for chawki rearing. It has succulent leaves and more leaf area compared to M_5 leaves. It yields about 30 tonnes/ha/yr (Anon, 1992).

The S_{36} mulberry variety is the most nutritive compared to local K_2, S_{30}, S_{41} and S_{54}.Further, S_{36} recorded more moisture (72.28%), total minerals (9.0%), less crude fibre (9.10%), reducing sugar (1.56) and more non-reducing sugar (11.31%), total sugar (11.31%), starch (10.0%), total carbohydrates (21.31%), water soluble protein (9.33%) and less total free amino acid (60.0 mg/100 mg) (Bose *et al.*, 1991).

When late age silkworm are fed with S_{36} leaves there was an increase in larval weight. high ERR, high cocoon weight and shell weight (Venkataramu, 1986).

S_{36} mulberry variety was raised on large scale in polythene bag by the forest department and distributed to the farmers of Kolar district at subsidized price. In the year 1996 farmers of Kolar district covered larger area under S_{36} variety and started feeding the leaves to all stages, which resulted in disease problem to the silkworm (Anon, 1997)

In this context, it was thought necessary to investigate the reasons and production constraints with respect to S_{36} variety of mulberry.Hence, it is proposed to undertake the studies with the following objectives.

1. To find out the Nutrient status of S_{36} and M_5 leaves
2. To find out the changes in micro climate by feeding only S_{36} leaves at all stages
3. To evaluate S_{36} variety for rearing performance of mulberry silkworm fed Throughtout instar.

REVIEW OF LITERATURE

II REVIEW OF LITERATURE

The literature pertaining to the present investigation on the Influence of S_{36} mulberry variety on the rearing performance of the silkworm *Bombyx mori* L and the related aspects are reviewed and presented under appropriate headings.

2.1 Nutritional value of mulberry varieties

Growth and development of *B. mori* larvae and ultimately the economic traits such as cocoon yield, cocoon and shell weight and silk percentage were greatly influenced by nutritional level of mulberry varieties (Perpiev, 1968; Krishnaswamy *et al.*, 1970).

The tetraploid and triploid mulberry varieties were superior in their nutritive value with higher protein, total sugar, reducing sugars and minerals (Seki and Oshikane, 1959; Das and Prasad, 1974).

Several workers obtained the higher values of protein and sugar in the feed which were known to favour better performance of silkworm growth and their cocoon crop (Legay, 1958; Ito, 1960; Horie, 1980).

Friend (1958) and Waldbauer (1968) also highlighted the importance of dietary moisture content and reported that phytophagous insects required high water intake for normal development and feeding of larvae with wilted foliage produced adverse effects.

Ito (1963) reported that the higher leaf moisture was known to increase the amount of leaf ingestion and digestion capacity of silkworm through its olfactory and gustatory stimulative effect. while, low leaf moisture was found to affect the growth and development of silkworms (Sengupta *et al*., 1971).

Rangaswamy *et al*. (1976) compared tender, mature and bottom leaf for nutritive substances in different mulberry varieties. The top and tender leaves contained more crude protein, moisture, reducing and non-reducing sugars than mature and bottom laves while mineral contents increased with increasing maturity. Similar observations were also reported by Nakajima (1931), Iwanari and Ohno (1969), Fotadar *et al*. (1989) and Liaw *et al*. (1991).

Low level of protein and water content and high levels of fibre and carbohydrates in mature leaf did not favour the optimal growth in *B. mori* as observed by Li and Sang (1984) and Sreedhara *et al*. (1988).

Dale (1985) and Bieleski and Redgwell (1985) have clearly shown that mature leaf rapidly translocates carbohydrates to the younger leaves, increases carbohydrate content in tender and medium leaves of high stem prunning showed that the process of translocation of carbohydrates from mature leaf to younger leaf may be accelerated.

The moisture content is an important parameter for deciding good leaf and for rearing young age silkworms. Moisture percentage ranged from 73 per cent (Berhampur-S) to 78 per cent (S_{41}) where as S_{30} and S_{36} showed 74 per cent of leaf moisture (Anon, 1983).

Sastry *et al*. (1988) noticed that the varieties also differ in loss of moisture from harvested leaf. The loss of moisture during the period between 9 AM to 4 PM was determined and found to be less in S_{30} (17.61 + 0.94%) and S_{36} (23.17 $\pm$ 0.98%).

According to Bongale *et al.* (1991) the quality of feed was determined by its major components such as water, carbohydrates, proteins, mineral elements, fats, amino acids and vitamins. It has been observed that the top tender leaves are nutritionally richer compared to medium and mature leaves. The soluble proteins, sugars and moisture content being highest in top tender leaves. These components decrease gradually with maturity.

Bose *et al.* (1991) observed that S_{36} mulberry variety is the most nutritive compared to local, Kanva-2, S_{30}, S_{41} and S_{54}. Further they stated that S_{36} recorded more moisture (72.28%), total minerals (9.0%), less crude fibre (9.10), reducing sugar (1.56) and more non-reducing sugar (11.31%), total sugar (11.31%), starch (10%), total carbohydrates (21.31%), water soluble protein (9.33%) and less total free amino acids (60.0 mg/100mg).

A significant increase in soluble sugar and starch content in tender and medium leaf of high stem pruning was observed compared to bottom pruning (Ratna Sen *et al.*, 1991).

Among different nutritive parameters the leaf moisture content, moisture retention, sugar and protein contents in addition to sugar protein ratio were of special significance with respect to larval weight and moulting ratio of young age larvae (Chaluvachari and Bongale, 1996).

Bongale *et al.* (1997) observed maximum values of leaf moisture content (74.9 to 83.3%) in tender leaves compared to other growth periods and maturity levels in respect of M_5, S_{54}, S_{36}, RFS-135, RFS-175, Berhampur-S and Berhampur-763 (71.6 to 75.5%, 69.7 to 74.7%, 68.3 to 74.1% and 68.0 to 73.4%) representing medium, mature, over mature-1 (90 days) and over mature-2 (120 days) respectively and maximum values of leaf protein and sugar contents were also recorded in tender leaves-2 (45 days). This has been also reported by Nakajima (1931), Shreedhara *et al.*, (1988), Sinha *et al.*, (1993) and Chaluvachari and Bongale (1996).

2.2 Effect of S_{36} leaves feeding on growth and development of the silkworm

Silkworm performed differently with respect to growth, cocoon formation and silk properties when different varieties of mulberry leaves were fed (Anon., 1976b). The new strains showed superior results compared to Kanva-2 and local in respect of survival rate, cocoon weight, shell weight when leaves of S_{30} variety were fed resulting in maximum larval weight (33.88g) followed by S_{36} (33.80g) whereas Kanva-2 and local gave 28.40g and 27.90g weight respectively for ten mature worms. Single cocoon weight was maximum in S_{30} (1.42g) followed by S_{36} (1.36g) (Anon., 1976a).

The mulberry strains viz., S_{30}, S_{36} S_{41} and S_{54} have yielded 50-60 per cent more yield over M_5 and nearly 100 per cent increase over Mysore local under irrigated conditions (Anon, 1976a).

Opender Koul *et al.* (1979) evaluated eight varieties of mulberry viz., S_{30}, S_{36}, S_{41}, S_{54} English Black x Kosen, Assambola x Philippines, Kanva-2 and local with Bivoltine hybrids for cocoon crop performance and incidence of loss due to disease. Yield for 10000 larvae by number and weight were maximum in Assambola x Philippines where as S_{30} and S_{36} gave highest single cocoon weight.

Venkataramu (1986) recorded the effect of different mulberry varieties on larval duration and cocoon characters of silkworms. In PM x NB_4D_2 S_{54} recorded highest mature larval weight (29.63 g) cocoon weight (1.707 g), pupal weight (1.398 g) shell weight (0.290 g) and shell percentage (16.82) followed by S_{36} variety shows 10 larval weight (26.240 g), cocoon weight (1.630g), pupal weight (1.387g), shell weight (0.276) and shell percentage (16.32). Whereas PM x NB_4D_2 on S_{36} variety recorded maximum 10 mature larval weight (29.524). S_{54} recorded highest single cocoon weight (1.685 g) and pupal weight (1.392 g) followed by S_{30} and S_{36} varieties.

Bheemanna (1986) studied the influence of mulberry varieties on certain seed technological parameters such as cocoon weight and number of eggs per ovariole. Higher cocoon weight (2.304g) resulted in NB_4D_2 breed on S_{41} while ovariole length and highest number of eggs (463) was more in NB_4D_2 (13.080cm) was on S_{36} variety followed by K_2 (460.50).

Govindan *et al.* (1987) conducted an experiments by feeding leaves of six mulberry varieties viz., S_{30}, S_{36}, S_{41}, S_{54} and Kanva-2 to three different breeds of silkworm viz., NB_4D_2, NB_7 and NB_{18}. The S_{41} variety gave higher cocoon weight (2.120g). The S_{36} variety gave (1.8881g) of single cocoon weight and also S_{36} variety supported for maximum fecundity (602.66g) the varieties S_{41} and S_{54} yielded similar fecundity of 524.50 and 532.33 eggs respectively.

Tayade *et al.* (1988) evaluated some improved strains of mulberry by feeding experiments under Marathwada conditions. The mulberry variety S_{54} gave highest 10 larval weight (30.350g) and recorded highest fecundity (463.00 eggs). S_{41} and S_{36} varieties gave highest shell weight and shell percentage respectively, the overall better rearing results was yielded by the varieties S_{36} and S_{41}.

Bheemanna *et al.* (1989) opined that feeding the NB_7 and NB_{18} race with mulberry variety S_{36} resulted in maximum progression to 4^{th} instar. Except in the rainy season, maximum larval weight was achieved with NB_7 race fed on S_{41} mulberry variety. The most effective rate of rearing was obtained with breed NB_7 fed on S_{41} and S_{54} varieties.

Das and Vijayraghavan (1990) observed that S_{36}, S_{41} and S_{54} genotypes were superior to M_5. The genotype S_{36} was the best. The genotype S_{36} recorded highest larval weight (28.68g/10 larvae), ERR (7573 / 1000 larvae), less larval duration (26.40 days), highest single cocoon weight (1.32g), single shell weight (0.200g) and shell percentage (17.53%). The best rearing results were obtained during August to January. While April to May yielded the least values with regard to all economic characters.

Giridar and Sivarami Reddy (1990) studied the ERR in Bivoltine breeds on different mulberry varieties. Among the silkworm breeds studied, NB_7 registered highest ERR both by number and weight, where as the lowest was observed in KA variety. Values were intermediate for NB_4D_2 and NB_{18}. Among the mulberry varieties studied, S_{36} and S_{30} had topped in the order followed by S_{54}. All the silkworm breeds registered higher ERR values with S_{36} mulberry variety, while the lower ERR was observed with S_{41} variety.

Muralidhara (1990) compared different feeding methods on growth attributes of Bivoltine silkworm breed NB_4D_2. Most of the economic characters like cocoon weight (1.494g), pupal weight (1.200g), shell weight (0.275g) and filament length (802.59m) were found to be high in case of selection varieties S_{36} and S_{30} and nutritionally superior to Kanva-2, S_{54} and S_{41}.

Satyanarayana Raju *et al.* (1990) evaluated four new mulberry varieties through silkworm rearing under irrigated conditions. The performance of the mulberry variety S_{30} and S_{36} were better than S_{41} and K_2 for many economic characters.

Giridar *et al.* (1991) opined that silkworm breeds reared on the mulberry genotypes namely S_{36}, S_{30} and S_{54} have shown higher values for larval and shell weight. S_{36} recorded high ERR (9250/10000 larvae) and single cocoon weight (1.345g). They also investigated the growth in volume of larvae of 4 Bivoltine breeds of *B. mori* and their silk glands on 5 varieties of mulberry and revealed that the breeds NB_7 and NB_{18} had higher larval volume (4.39 ml), silk gland volume (1.15 ml) and silk gland ratio (26.20%) on S_{36} mulberry variety.

Mallikarjunappa *et al.* (1992) evaluated selected mulberry varieties for their suitability for chawki rearing. The mulberry varieties evaluated were S_{30}, S_{36}, Viswa with M_5 as check. The four mulberry varieties evaluated have not exhibited any effect on the moulting test parameters. But the differences between the crops have been found to be quite significant. S_{36} variety gave maximum larval weight (41.67g) cocoon number (8609/10000 worms), cocoon yield (15.2 kg), single cocoon weight (1.900 g), single shell weight (0.400g) and cocoon shell ratio (19.2%).

Mala *et al.* (1992) evaluated the high yielding selection varieties of mulberry (S_{30}, S_{36}, S_{41} and S_{54}) for chawki rearing of bivoltine hybrids. At farmers level indicated that the feed quality of S_{36} and S_{30} are comparatively better than K_2, S_{41} and S_{54}.

Sarathchandra *et al.* (1992) have evaluated six elite mulberry varieties viz., S_{36}, RFS_{135}, English Black, Sujanpur-5, C-776 and S-799 by bioassay studies. The varieties S_{36}, RFS-135 and C-776 proved to be superior which gave cocoon yield of 15.500, 14.890 and 14.274 kg per 10000 larvae brushed respectively. S_{36} showed significantly higher shell ratio (23.1%) while C-776 and RFS-135 showed higher single cocoon weight (1.774g and 1.817 g respectively).

Bheemanna *et al.* (1997) reported that the influence of mulberry varieties viz, S_{30}, S_{36}, S_{41}, S_{54}, Kanva-2 and Mysore local on some quantitative traits of bivoltine breeds (NB_4D_2, NB_7 and NB_{18}). Irrespective of silkworm breeds the highest larval weight (49.35g/10 worms), cocoon weight (24.66 g/10 cocoons) and fecundity (618.70 eggs) were obtained with S_{41}, Mysore local and S_{36} respectively. Cocoon shell percentage was maximum when reared on S_{36}, S_{30} and S_{41} (22.67-21.30%). While single cocoon filament length was highest in S_{54}, S_{36} and S_{41} (1133-1200 cm). In general the performance of NB_4D_2 on S_{41} and S_{36} was the best.

2.3 Natural enemies of silkworm, *B. mori*

In India, there was 30-40 per cent of the silkworm crop loss due to diseases (Vaidya, 1960). The chief diseases affecting the mulberry silkworms are Flacherie, Muscardine, Grasserie and Pebrine of which, Flacherie is more prevalent than the others (Janakiraman, 1961).

Sidhu and Singh (1968) estimated a crop loss of 30-40 per cent due to viral diseases. The incidence of diseases like Grasserie, Flacherie was highest during May to July (Anon., 1979).

Satish (1984) noticed that the nuclear polyhedrons prevailed throughout the year under large scale rearings, maximum incidence of 10.44 per cent was noticed during June-July.

According to Subba Rao *et al.* (1991) the total loss due to diseases ranged from 0.58 to 11.18 per cent in Murshidabad, 2.03 to 12.44 per cent in Bisbhum and 3.65-15.58 per cent in Malda district of West Bengal. The mean per cent mortality due to disease in three district was 3.2 in Falbooni crop (Feb – Mar, 1987), 10.29 in Jaishta crop (May-June, 1987) and 2.09 in Agrahayani crop (Oct – Nov., 1987). During pre-monsoon season (May-June) the silkworm crops were affected due to Flacherie, Muscardine and Grasserie diseases.

Swami and Nagaraj (1992) found that around Chandragiri and Chittoor in Andhra pradesh, grassarie was a serious disease (17.2%) in rainy (July-Oct.) season. Muscardine was significantly higher in winter (Nov-Feb) with 22.70 per cent. During summer (March-May) bacterial flacherie disease was maximum being 24.3 per cent.

Kolar (1995) opined that the Dec-Jan rearing season was most favourable that resulted in less incidence of natural enemies like muscardine (7.55%), Grasserie (3.64%) and flacherie (2.22%).

MATERIAL AND METHODS

III. MATERIAL AND METHODS

A study on Influence of S_{36} mulberry variety on the rearing performance of the silkworm *Bombyx mori* L. was carried out during the year 1998-1999 in the Department of Sericulture University of Agricultural Sciences, GKVK, Bangalore. The details of the material used and methodology followed during the course of investigations are presented in this chapter.

3.1 GENERAL DESCRIPTION

3.1.1 EXPERIMENTAL SITE

The field experiment was conducted in Block B. of the Main Research Station, University of Agricultural Sciences, Hebbal, located at 12^0 58^1 North latitude and 77^0 37^1 East longitude at an altitude of 899 metres above mean sea level.

3.1.2 CROPPING HISTORY

The experiment was conducted in established six months old mulberry crop. The treatment details as mentioned in item 3.2.1 were imposed on established plantation.

3.13 ENVIRONMENTAL CONDITIONS

The monthly weather data on temperature (^{0}C) and relative humidity was recorded in the rearing room and in the rearing tray during morning between 8-9 AM afternoon between 1-2 PM and night between 8-9 PM in all the three crops with the help of dry and wet bulb thermometer. Mean weather data presented in Table 2a and 2b and complete data are presented in Annexure I, II, III, IV, V and VI.

3.1.4 VARIETAL DESCRIPTION

M_5 (kanva-2)

The variety M_5 (Mysore selection No-5) was evolved by the CSR & TI, Mysore. It was selected from the seedlings of Mysore local. This variety has unlobed succulent leaves with serrated margin and shorter internodal length. It bears female flower. It responds well to the manurial inputs and cultural practices. It yields 25 per cent higher than the Mysore local variety (Anon., 1976 a).

S_{36}

The variety S_{36} (selection No-36) was evolved by the CSR & T_I, Mysore. This variety was introduced exclusively for rearing chawki silkworms. It has serrated margin and succulent leaves. S_{36} variety has longer inter nodal length compared to M_5. It yields about 30 tonns/ha/yr (Anon., 1992).

3.1.5 EXPERIMENTAL DESIGN

The experiment was laid out as Randomised Complete Block Design (RCBD)

3.2 DETAILS OF EXPERIMENTS

Required number of disease free layings of cross breed (PM x NB_4D_2) were procured from Venugopal silkworm seed producing centre (VSSPC) Bangalore. The cross breed was reared on two mulberry varieties grown under irrigated conditions viz., M_5 (kanva-2) and S_{36} in four replications with the following treatments.

Plate No.1 Mulberry Variety S_{36}

Plate No. 2 Mulberry Variety M_5

3.2.1 TREATMENT DETAILS

T_1 – Feeding 1st instar with S_{36} and remaining instars with M_5

T_2 – Feeding I and II instar with S_{36} and remaining instars with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining instars with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

3.3 REARING OF SILKWORMS

3.3.1 DISINFECTION

A week prior to hatching of eggs, the silkworm rearing room and equipments were disinfected with 4 per cent formalin solution @ of 800 ml per 10 square meter using Gator Rocker Sprayer for effective disinfection. The room was made air tight for 48 hours by sealing the doors windows and ventilators with paper. The rearing room was kept open for 24 hours and then used for silkworm rearing.

3.4 CHOICE OF SILKWORM BREED

For the experiments disease free laying (DFL's) of commercial silkworm cross breed (PM x NB_4D_2) were obtained from Venugopal silkworm seed producing centre (VSSPC) Bangalore

3.5 INCUBATION AND BRUSHING

Disease free layings were kept on paraffin paper in wooden tray and incubated at 26 ± 1^{0}C and 75-85 per cent relative humidity. To maintain optimum RH, moist foam rubber strips were placed around the egg cards in the rearing tray and covered with paraffin paper. The eggs were black boxed for 24 hours in pin head stage followed by exposure to room light during morning to obtain uniform and maximum hatching.

Ensuring two hours after hatching by adopting tapping method 'ants' of ten dfl's were transfered to wooden trays having a paraffin paper on its floor and wet foam rubber strips all along the inner edges of the trays. The larvae were divided into 200 each for replication before giving first feed. Five rearing trays were accommodated in the rearing stand. The leaves of S_{36} and M_5 mulberry were harvested individually in the cool hours of the day and preserved in leaf chamber separately. Fourth to seventh leaves from top were selected for chawki feeding. As the worms grew the leaves plucked from the middle part of the plant from seventh leaf downwards were provided as food to later stages.

3.6 REARING

In the experiment three rearings were carried during January to July the details of rearing periods are as follows.

- First rearing – 1st Jan to 1st Feb 1999
- Second rearing – 21st May to 22nd June 1999
- Third rearing – 2nd June to 2nd July 1999

The silkworm rearing was taken up as per the procedure outlined in the package of practices (Anon., 1993)

The cross breed silkworm (PM x NB_4D_2) was reared in all three rearings. Eight hundred worms were reared in each treatment in four replications. The worms were reared by leaf feeding upto spinning. Silkworms were fed four times a day (8 AM, 12 Noon, 4 PM and 8 PM) with suitable mulberry leaves. Lime powder was dusted over the rearing seat to keep the silkworm bed dry at the time of settling for

Plate No. 3 Feeding treatment No–3 (control) silkworms with M_5 mulberry leaves.

Plate No.4 Feeding treatment No–4 silkworms with S_{36} mulberry leaves

moult. The cleaning of rearing bed was done once, twice, thrice, four times and daily once during first, second, third, fourth and fifth instar respectively.

The ripe worms were hand picked and mounted on bamboo montages at the rate of 50 worms per 30 cm^2 and cocoons were harvested on 6^{th} day after mounting.

3.7 SILKWORM PARAMETERS

In this experiment, the following observations were made

- 10 larval weight in all instars before and after each moult
- Per cent disease incidence
- Effective rate of rearing
- Total disease percentage
- Cocoon weight (g)
- Pupal weight (g)
- Shell percentage (%)
- Total filament length (m)
- Denier
- Raw silk percentage (%)

3.8 METHOD OF RECORDING THE DATA ON DIFFERENT PARAMETERS OF SILKWORM

3.8.1 LARVAL WEIGHT (g)

Ten larval weight was recorded twice, just before settling for moult in all instars and after each moult and mature larval weight was recorded one day prior to spinning in all the treatments with the help of an electronic balance.

3.8.2 DISEASE INCIDENCE

Disease incidence was recorded every day before feeding the silkworms. Every tray was observed and infected silkworms were counted for the various diseases viz., murcardine, grasserie, flacherie and pebrine. The disease incidence was calculated by the formula.

$$\text{Disease percentage} = \frac{\text{Number of worms infected}}{\text{Total number of worms reared}} \times 100$$

3.8.3 EFFECTIVE RATE OF REARING (ERR)

The hatching percentage was recorded to know the number of worms brushed from each laying. After successful rearing, number of silkworms that spun, number of cocoons harvested were recorded. The effective rate of rearing was calculated by counting the number of cocoons formed and the number of worms brushed and expressed as percentage by adopting the formula

$$\text{ERR} = \frac{\text{Number of cocoons obtained}}{\text{Number of worms brushed}} \times 100$$

3.8.4 COCOON WEIGHT (g)

After five days of mounting 10 cocoons were harvested at random from each treatment replication wise and weighed the mean cocoon weight was recorded

3.8.5 PUPAL WEIGHT (g)

Ten cocoons were randomly selected from each treatment and in each replication and weighed. The mean pupal weight was recorded

Plate No. 5 Cocoons of treatment No–3 (control)

Plate No.6 Cocoons of treatment No–4

3.8.6 SHELL PERCENTAGE (%)

After removing the pupae and excuviae by cutting open the cocoons at one end the shells were weighed mean shell weight was worked out and the shell percentage was calculated using the formula

$$\text{Shell percentage} = \frac{\text{Mean weight of cocoon shell (g)}}{\text{Mean weight of whole cocoon (g)}} \times 100$$

3.8.7 TOTAL FILAMENT LENGTH (M)

Ten cocoons were reeled separately from each replication with the help of an Eupprovette and filament length (Number of revolutions on eupporvette x 1.125 m) was recorded.

3.8.8 DENIER

It was calculated by using the formula

$$\text{Denier} = \frac{\text{Single cocoon filament weight}}{\text{Single cocoon filament length}} \times 900$$

3.8.9 RAW SILK PERCENTAGE

Raw silk yarn is made up of a number of individual filaments which are simultaneously reeled. Normally filaments from 8-10, 10-12 or even 14 to 16 cocoons are reveled together to make a commercial raw silk depending upon the size of the raw silk required in the weaving industry

Raw silk percentage was calculated by using the formula

$$\text{Raw silk percentage} = \frac{\text{Raw silk weight}}{\text{Shell weight}} \times 100$$

3.9 BIO-CHEMICAL CONSTITUENTS OF S_{36} AND M_5 MULBERRY VARIETIES

Bio-chemical constituents such as total soluble sugar, chlorophyll, crude protein, carbohydrate, crude fibre and moisture in the leaves of S_{36} and M_5 mulberry varieties of both tender and mature leaves were estimated. The bio-chemical analysis was carried out in the Department of crop physiology, University of Agricultural Sciences, Bangalore

3.9.1 COLLECTION OF MULBERRY LEAF SAMPLE

Tender and mature leaves of S_{36} and M_5were collected in the month of June. The tender leaf sample was collected from top fourth to seventh and mature leaf sample from middle branches. Each sample was taken in a paper cover and dried under shade for three days, then the leaf samples were kept in an oven at 87 $\pm 1^0$C for 24 hours to remove the moisture. The samples were made into fine powder using a grinder. The samples of both tender and mature leaves were stored in polythene containers with air tight lid and used for chemical anaysis.

3.9.2 EXTRACTION OF PLANT MATERIAL FOR ESTIMATION OF TOTAL SOLUBLE SUGARS.

One gram of dried leaf powder of each variety was boiled for 30 minutes in 25 ml of 80 per cent alcohol on hot water both, supernatant extract was decanted into another flask and the residue was again re-extracted with small quantity of hot alcohol. Both the extracts were pooled and filtered through Watman No-1 filter paper. The final volume was made upto 25 ml and this extract was directly used to estimate the total soluble sugars.

Aliquot of the standard sugar solution containing 80 µg/ml were pipetted out into a series of test tubes. The volume in each test tube was made upto 1.0 ml by the addition of distilled water. In another test tube 1.0 ml of distilled water was pipetted out to serve as blank 0.5 ml of phenol reagent was added to each test tube and mixed well. Then 5 ml of concentrated H_2SO_4 was added to each test tube and allowed to stand for 10 minutes. The test tubes were shaken well and placed in a water bath at 25-30^{0}C for 10-20 minutes. The absorbance of the coloured solution was read in spectronic–21 at 490 nm. The standard curve was prepared by plotting absorbance value against the concentration of sugar present in standard sugar solution.

In the same manner 0.1ml of the above plant extract was treated. The sugar present in the plant extract was estimated from the standard curve (Dubai *et al.*, 1956)

REAGENTS

1. Phenol reagent

Added 95 ml of water and 5 g of redistilled phenol and stirred to dissolve.

2. Conc. H_2SO_4

Reagent grade 95.5%

Specific gravity 1.84

3. Standard sugar solution

A 0.4% sugar solution was prepared by dissolving 400 mg of sugar in water and the solution was made up to 100ml volume in a volumetric flask. This diluted solution contained 80 µg sugar/ml and was used to prepare the standard curve.

3.9.3 ESTIMATION OF CRUDE PROTEIN

It was estimated by determining nitrogen content in 0.5 gram sample by Micro-Kjeldhal method. The crude protein content was calculated by multiplying the per cent nitrogen of the sample with a factor 6.25 (A.O.A.C. 1970).

3.9.4 ESTMATION OF CRUDE FIBER

Five grams of plant material was taken into a 600 ml tall beaker into which 200 ml of 1.25 per cent H_2SO_4 was added. The contents were boiled for 30 minutes by maintaining the constant volume by adding H_2SO_4 as and when required. The contents were filtered through a cloth and made acid free. The contents were transferred back to the beaker. While transferring, kept the cloth on a watch glass and scraped the contents to the beaker with spatula. To which 200ml of 1.25 per cent NaoH was added and boiled for 30 minutes by maintaining the constant volume. The contents were filtered to make it free of alkali by washing with distilled water. Placed the cloth on a funnel along with the sample, added about 50 ml of alcohol to remove fat if any present in the sample. Transferred the contents to a previously weighted silica crucible and dried the contents in a hot air oven and recorded the dry weight. Ignited the contents using a burner till a white ash was obtained. The contents were cooled and the ash weighed.

Weight of empty silica crucible = ‘a’ gram
Weight of crucible + Crude fibre (before ignition) = ‘b’ gram
Weight of crucible + ash (after ignition) = ‘c’ gram

c-a = mineral material
b-a = crude organic matter
(b-a)-(c-a) = crude fibre

3.9.5 MOISTURE PERCENTAGE OF LEAF

The percentage of moisture in different categories of leaves viz., top (Fourth to seventh) and mature leaves of middle branches was estimated by taking fresh weight and oven dry weight of the leaves on fresh weight basis (A.O.A.C. 1970)

$$\text{Moisture (\%)} = \frac{\text{Fresh weight} - \text{Dry weight}}{\text{Fresh weight}} \times 100$$

3.9.6 ESTIMATION OF CHLOROPHYLL

Green fresh leaf sample of 0.5 g was accurately weighed and taken in a test tube with 6 ml of acetone and 4 ml dimethyl sulphoxide. Test tubes were plugged and kept in dark condition over night. Total chlorophyll content was estimated by recording the absorbance in spectrophotometer – 21 at 663 nm and 645 nm by using the following formula (Arnon., 1949).

Total chlorophyll = 20.2 (D6450)+8.02 (D643) X V/1000xw

Where, D 645 and D 643 are the absorbancy values at respective nanometers

V = Volume made up (ml)

W = Weight of fresh sample (g)

For chlorophyll 'a'

Mg/g fresh weight = 12.7 (D663)-2.69 (D645) X V/1000xW

For chlorophyll 'b'

Mg/g fresh weight = 22.9 (D645)-4.68 (D663) X V/1000xW

3.9.7 ESTIMATION OF CARBOHYDRATES

Five grams of fresh leaves was taken into a 250 ml beaker into which 35 ml of 95 percent ethanol was added. The contents were boiled in a reflux condensor for 10 min to take out the tissues and extracted in 80 percentage ethanol for 10 min. Then centrifuged the extract at 5000 rpm for 10 min and collected the clear supernatant. Pooled the two fractions of alcohol and completely evaporated to dryness under vacuum at 30^0C using fresh evaporates. After that redissolve the pellet in a 50 ml of distilled water, immediately check the pH of the solution using a pH paper and adjust the pH to 7. The carbohydrate content of the extract estimated directly on the extract by chromatography

3.10 STATISTICAL ANALYSIS

The experimental data were statistically analysed by the procedure out lined by Sundarraj *et al.* (1972). Level of significance used in F test was 0.05 level of probability.

EXPERIMENTAL RESULTS

IV. EXPERIMENTAL RESULTS

The results of the investigations on "Influence of S_{36} mulberry variety on the rearing performances of the silkworm, *Bombyx mori* L" was conducted during 1998-1999 at Main Research Station, Hebbal, University of Agricultural Sciences, Bangalore. Results of the investigations are presented here under following headings.

4.1 Nutrient status of mulberry leaves

The results on nutrient status of tender leaves (fourth to seventh from top) and mature leaves (from eighth leaf onwards) were analyzed and presented. Since the composite samples were taken for chemical analysis, the data have not been analysed statistically. The data are presented in Table I.

4.1.1 Moisture percentage

The moisture percentage in the tender leaves ranged from 73.71 to 74.51. The highest moisture percentage of 74.51 was recorded in the tender leaves of S_{36} mulberry variety followed by 73.71 percentage in M_5 leaves. In mature leaves, the maximum percentage ranged from 65.42 to 69.81. The maximum moisture percentage of 69.81 was observed in S_{36} leaves followed by 65.42 percentage in M_5 leaves with regard to mean percentage of both tender and mature leaves, the maximum moisture percentage was observed in S_{36} (72.16) followed by M_5 (69.56) leaves.

4.1.2 Crude protein

The crude protein content was higher in tender leaves than mature leaves in both the varieties and ranged from 22.85 to 23.93. In tender leaves, highest crude protein was recorded in S_{36} (23.93)

Table I. Nutritional composition of S_{36} and M_5 mulberry leaves

FOLIAR CONSTITUENTS	M_5 TENDER	M_5 MATURE	M_5 MEAN	S_{36} TENDER	S_{36} MATURE	S_{36} MEAN
Moisture content (%)	73.71	65.42	69.56	74.51	69.81	72.16
Crude protein (%)	22.85	18.92	20.88	23.93	20.91	22.42
Total soluble sugar (%)	12.50	9.53	11.01	11.31	7.38	9.34
Chlorophyll – a (mg/fw)	1.36	1.66	1.51	1.70	1.82	1.76
Chlorophyll – b (mg/fw)	0.82	0.79	0.80	0.91	0.84	0.87
Total chlorophyll (mg/fw)	2.18	2.45	2.31	2.61	2.66	2.63
Crude fibre (%)	8.52	11.40	9.96	9.10	12.73	10.91
Carbohydrates (%)	16.99	21.31	19.95	18.12	23.00	20.56

followed by M_5 (22.85) leaves. In mature leaves, the crude protein content ranged from 18.92 to 20.91. The maximum percentage of crude protein (20.91) was observed in S_{36} variety followed by 18.92 in M_5 leaves. The mean crude protein of tender and mature leaves ranged from 22.42 in S_{36} to 20.88 in M_5 leaves.

4.1.3 Total soluble sugar

In tender leaves, total sugar ranged from 11.31 to 12.50 per cent. The highest percentage of total sugar was recorded in M_5 (12.50) leaves followed by S_{36} (11.31) leaves, whereas in mature leaves, the total sugar was highest in M_5 (9.53). The lowest was in S_{36} (7.38) leaves. The mean total soluble sugars of both tender and mature leaves ranged from 9.34 to 11.01 per cent. M_5 recorded 11.01 percentage of total soluble sugar and was lowest in S_{36} (9.34) leaves.

4.1.4.1 Chlorophyll 'a' (mg/gfw)

In tender leaves, chlorophyll 'a' content was highest in S_{36} (1.70) followed by M_5 (1.36). Among mature leaves, the chlorophyll 'a' content was highest in S_{36} (1.82) followed by M_5 (1.66). The mean chlorophyll 'a' content of both tender and mature leaves ranged from 1.51 in M_5 leaves to 1.76 in S_{36} leaves.

4.1.4.2 Chlorophyll 'b' (mg/gfw)

The chlorophyll 'b' content was maximum in tender leaves of S_{36} (0.91) followed by M_5 (0.82). The highest chlorophyll 'b' content of mature leaves varied from 0.79 to 0.84. The S_{36} (0.84) gave maximum chlorophyll 'b' content followed by M_5 (0.79). The mean chlorophyll 'b' content was minimum (0.80) in M_5 leaves and recorded maximum (0.87) in S_{36} variety.

4.1.4.3 Total chlorophyll (mg/fw)

In tender leaves, total chlorophyll content was maximum in S_{36} (2.61) followed by M_5 (2.18). Among mature leaves, the highest total chlorophyll content was in S_{36} (2.66) and lowest was recorded in M_5 (2.45). The mean total chlorophyll content of both tender and mature leaves was maximum in S_{36} (2.63) followed by M_5 (2.31).

4.1.5 Crude fibre

The crude fibre content was more in mature leaves than in tender leaves. In tender leaves, S_{36} recorded highest amount of crude fibre content (9.10) and the lowest was in M_5 (8.52). In mature leaves also S_{36} (12.73) recorded highest crude fibre and lowest was in M_5 (11.40). The mean crude fibre was also more in S_{36} (10.91) followed by M_5 (9.96) leaves.

4.1.6 Carbohydrates

The carbohydrates content was higher in matured leaves than tender leaves in both M_5 and S_{36} mulberry varieties. In tender leaves, carbohydrates percentage was more in S_{36} (18.12%) and lowest in M_5 (16.99) leaves. Among mature leaves, the carbohydrates percentage was maximum in S_{36} (23.00%) followed by M_5 (21.31%). The mean percentage of carbohydrates of both tender and mature leaves was maximum in S_{36} (20.56%) whereas, the lowest was observed in M_5 (19.15%) leaves.

4.2 Climatic conditions

The mean data of temperature and relative humidity was recorded in the rearing trays and as well as in the rearing room during morning

Table IIa Micro-climate (MEAN) changes in rearing trays as influenced by S_{36} mulberry variety

MONTHS	Micro-climate changes in the trays															
	Temperature (^0C)								Relative humidity (%)							
	Morning		Afternoon		Night		Mean		Morning		Afternoon		Night		Mean	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	21	18	22	20	21	18	21.33	18.66	89	62	75	59	83	65	82.33	62.00
February	19	19	20	20	19	19	19.33	19.33	89	84	66	61	74	69	76.33	71.33
May	20	18	22	20	19	17	20.33	18.33	84	69	84	62	78	69	82.00	66.66
June	20	17	21	20	18	17	19.66	18.00	84	69	84	67	84	74	84.00	70.00
July	19	17	20	20	18	18	19.00	18.33	84	69	84	79	78	74	82.00	74.00

Table IIb – Mean temperature and Relative humidity recorded in the rearing room at MRS Hebbal, Bangalore

MONTHS	Temperature (^0C)								Relative humidity (%)							
	Morning		Afternoon		Night		Mean		Morning		Afternoon		Night		Mean	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
January	21	18	23	20	21	18	21.66	18.66	89	70	79	67	83	64	83.66	67.00
February	20	20	21	21	20	20	20.33	20.33	89	89	70	70	74	74	77.66	77.66
May	21	19	23	21	20	18	21.33	19.33	89	70	71	67	83	69	81.00	68.66
June	21	18	23	21	19	18	21.00	19.00	89	70	75	67	83	69	82.33	68.66
July	19	18	21	21	19	19	19.66	19.33	83	70	75	75	69	69	77.00	74.33

(8-9 AM), afternoon (1-2 pm) and night (8-9 pm). The data have not been analysed statistically and presented in Table IIa and IIb.

4.2.1 Micro-climate changes as influenced by S_{36} mulberry variety

The mean temperature was maximum (21.33^{0}C) in the month of January and minimum (18.00%) in the month of June. The mean relative humidity was maximum (84.00%) in the month of June and minimum (62.00%) was recorded in the month of January.

4.2.2 Mean temperature and relative humidity in the rearing room

Temperature recorded was maximum (21.66^{0}C) during the month of January and minimum (19.66^{0}C) was recorded during the month of July. Whereas, the relative humidity recorded was maximum (83.66%) in the month of January and also minimum relative humidity was (67.00%) in the month of January.

4.3 Larval weight as influenced by S_{36} mulberry leaves

The mean weight of ten worms before and after each moult and at maturity as influenced by S_{36} mulberry leaves with different feeding method schedules are presented in Table III, IV and Fig. 1, 2. There was significant difference when the silkworms were reared on S_{36} leaves throughout the larval period than the other treatments.

4.3.1 Larval weight before and after first moult

Larval weight before and after first moult showed non-significant differences. Among the treatments, before first moult larval weight ranged from 0.058-0.059g, 0.048-0.049g and 0.058-0.059 at

Table III. Larval weight as influenced by S_{36} and M_5 mulberry leaves and their combinations

TREATMENTS	I – INSTAR								II – INSTAR							
	I-CROP		II-CROP		III-CROP		MEAN		I-CROP		II-CROP		III-CROP		MEAN	
	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M
T_1	0.059	0.057	0.048	0.046	0.058	0.056	0.055	0.053	0.270	0.266	0.259	0.256	0.270	0.267	0.266	0.263
T_2	0.059	0.057	0.049	0.047	0.058	0.056	0.055	0.053	0.271	0.267	0.261	0.257	0.273	0.270	0.268	0.264
T_3	0.059	0.057	0.048	0.046	0.059	0.057	0.055	0.053	0.275	0.271	0.266	0.262	0.278	0.275	0.273	0.269
T_4	0.059	0.057	0.048	0.046	0.058	0.056	0.055	0.053	0.276	0.272	0.268	0.264	0.277	0.274	0.273	0.270
T_5	0.058	0.056	0.048	0.046	0.058	0.056	0.054	0.052	0.268	0.264	0.259	0.254	0.267	0.264	0.264	0.260
F. test	NS	NS	NS	NS	NS	NS			*	*	*	*	*	*	*	*
SE.m ±	0.0006	0.0006	0.0005	0.0005	0.0004	0.0004			0.0009	0.0009	0.0005	0.0006	0.0007	0.0007		
CD at 5%	-	-	-	-	-	-			0.0027	0.0027	0.0015	0.0018	0.0021	0.0021		

T_1 – Feeding 1st instar with S_{36} and remaining with M_5

T_2 – Feeding I and II instar with S_{36} and remaining with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

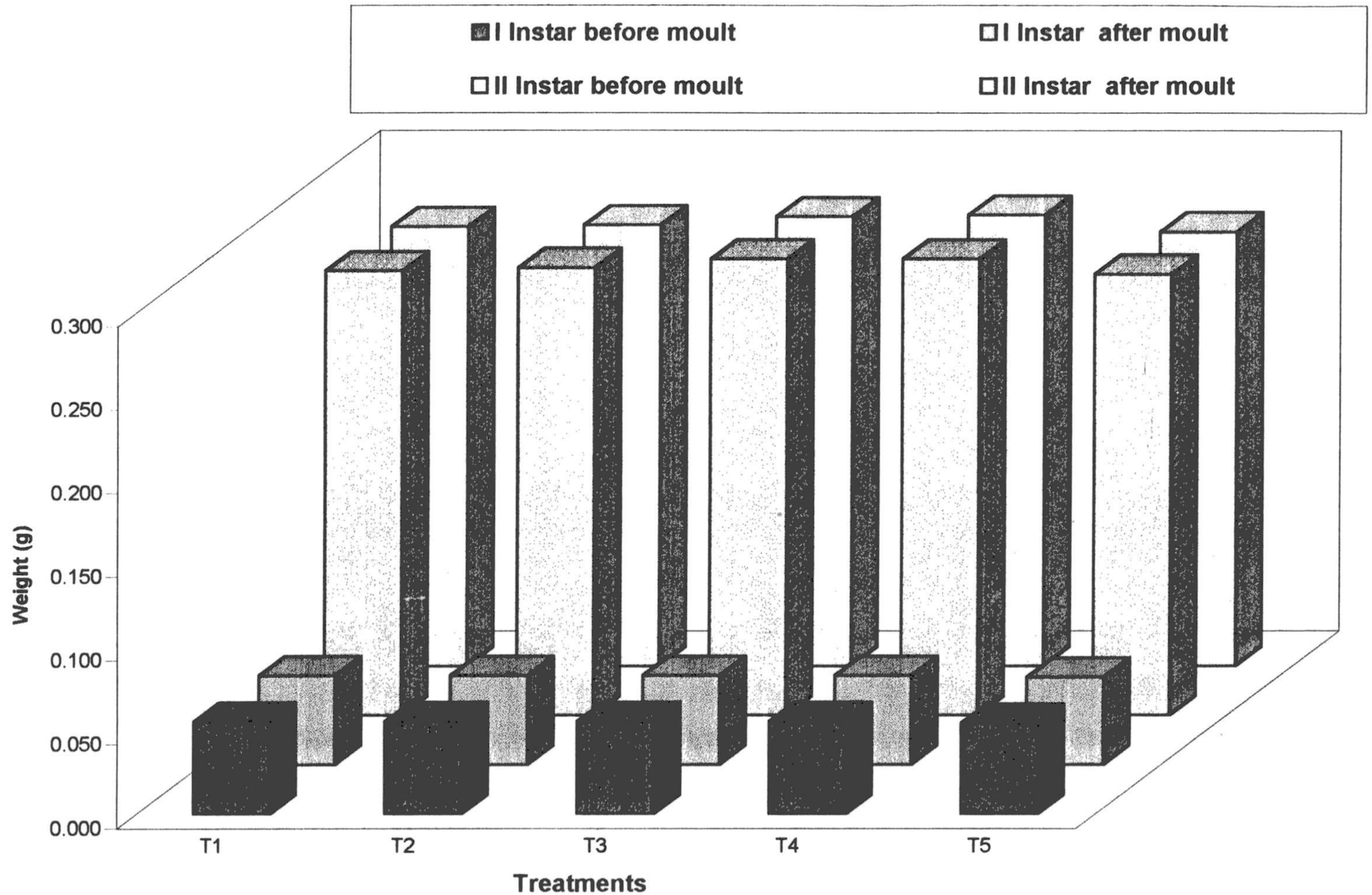

Fig.1 Mean larval weight as influenced by S_{36} and M_5 mulberry leaves and their combinations

before moult in the I, II and III crops respectively. Whereas, after first moult larval weights ranged from 0.056-0.057g, 0.046-0.047g and 0.056-0.057g in I, II and III crop respectively. In general, mean weight of first instar larval weight ranged from 0.054-0.055 and 0.052-0.053 at before and after moult respectively.

4.3.2 Larval weight before and after second moult

In the first crop, weight of ten larvae before moult showed significant treatmental difference. Maximum weight of larvae was obtained on T_4 (0.276) which was on par with T_3 (0.275) followed by T_2 (0.271), T_1 (0.270) and T_5 (0.268). Whereas, weight of ten larvae after moult also showed significant treatmental difference. The weights of T_4 (0.272) and T_3 (0.271) were on par with each other followed by T_2 (0.267) and T_1 (0.266). The lowest weight was recorded in T_5 (0.264).

In the second crop, weight of larvae at before moult showed significant differences. Highest larval weight was recorded in T_4 (0.268) over the weight of T_3 (0.266) followed by T_2 (0.261). However, weight of larvae after moult showed significant treatmental differences. T_4 (0.264) recorded highest larval weight when compared to T_3 (0.262). The weight of T_2 (0.257) and T_1 (0.256) were on par with each other. T_5 (0.254) recorded lowest larval weight after moult.

Further in third crop, T_4 (0.277) was on par with T_3 (0.278) showed significant differences over the treatments followed by T_2 (0.273) and T_1 (0.270). Lowest weight recorded in T_5 (0.267) at before moult. Whereas, weights after moult recorded significantly highest in T_3 (0.275) and T_4 (0.274) followed by T_2 (0.270), T_1 (0.267) and T_5 (0.264).

When averaged over three crops, weight of larvae at before moult recorded maximum in T_3 (0.273) and T_4 (0.273) followed by T_2 (0.268), T_1 (0.266) and T_5 (0.264). However, larval weight after moult was highest in T_4 (0.270) over the weight of T_3 (0.269) followed by T_2 (0.264), T_1 (0.263) and T_5 (0.260).

4.3.3 Larval weight before and after third moult

In the first crop, weight of ten larvae before moult showed significant treatmental differences. However, highest larval weight was recorded in T_4 (1.637) which was on par with T_3 (1.620) followed by T_2 (1.577) and T_1 (1.567). Lowest larval weight was recorded in T_5 (1.550), whereas weight of larvae after moult also showed significant treatmental differences. The weight of T_4 (1.587) and T_3 (1.570) were on par with each other followed by T_2 (1.527) and T_1 (1.517) the lowest weight was recorded in T_5 (1.500).

In the second crop, weight of larvae before moult recorded significant differences. Highest larval weight was recorded in T_4 (1.587) over the weight of T_3 (1.535) followed by T_2 (1.440) was on par with T_1 (1.437) as well as T_5 (1.435), whereas, weight of larvae after moult T_4 (1.527) recorded highest larval weight when compared to T_3 (1.475) followed by T_1 (1.377), T_2 (1.380) and T_5 (1.376) were on par with each other.

Further, in the third crop, weight of larvae before moult, T_4 (1.690) and T_3 (1.678) recorded significantly higher larval weight over the weight of T_2 (1.612), T_1 (1.595) and T_5 (1.587) there were on par with each other. However, weight of larvae after moult T_4 (1.640) as well as T_3 (1.635) recorded significantly more larval weight over the weight of T_2 (1.560). The weight of T_1 (1.545) was on par with T_5 (1.542).

However, maximum mean weight of larvae before moult was recorded maximum in T_4 (1.638) when compared to T_3 (1.614) followed by T_2 (1.543) and T_1 (1.533). Lowest weight was recorded in T_5 (1.524). whereas, weight of larvae after moult was recorded more in T_4 (1.584) followed by T_3 (1.560), T_2 (1.489) T_1 (1.479) and T_5 (1.472).

4.3.4 Larval weight before and after fourth moult

In first crop, weight of larvae before moult recorded highest larval weight in T_4 (7.082) as compared to T_3 (6.857). Neverthless, weight of larvae in T_2 (6.822) was on par with T_1 (6.812) as well as T_5 (6.790), whereas, weight of larvae after moult T_4 (7.005) recorded significantly highest when compared to T_3 (6.787) followed by T_2 (6.750) was on par with T_1 (6.742) as well as T_5 (6.720).

In the second crop, the weight of larvae before moult T_4 (6.487) was recorded significantly higher as compared to T_3 (6.372) followed by T_2 (6.325). The weight of T_5 (6.292) was on par with T_1 (6.285). whereas, weight of larvae after moult, T_4 (6.407) recorded significantly over the weight of T_3 (6.292) as well as T_2 (6.245), the weight of T_5 (6.212) was on par with T_1 (6.205).

Further, in the third crop, the weight of larvae before moult T_4 (7.127) recorded significantly over the weight of T_3 (6.945), while T_2 (6.855) was on par with T_5 (6.837) as well as T_1 (6.812) whereas, weight of larvae after moult T_4 (7.052) recorded significantly higher when compared to T_3 (6.875). Neverthless, T_2 (6.785) was on par with T_5 (6.767) as well as T_1 (6.740).

When averaged over three crops, weight of larvae before moult T_4 (6.898) recorded maximum larval weight as compared to T_3 (6.724) followed by T_2 (6.667), T_5 (6.639) and T_1 (6.636). Whereas, weight of larvae after moult, we found same treatmental differences as we seen at

IV continuation

TREATMENTS	III – INSTAR								IV – INSTAR							
	I-CROP		II-CROP		III-CROP		MEAN		I-CROP		II-CROP		III-CROP		MEAN	
	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M	B.M	A.M
T_1	1.567	1.517	1.437	1.377	1.595	1.545	1.533	1.479	6.812	6.742	6.285	6.205	6.812	6.740	6.636	6.562
T_2	1.577	1.527	1.440	1.380	1.612	1.560	1.543	1.489	6.822	6.750	6.325	6.245	6.855	6.785	6.667	6.59
T_3	1.620	1.570	1.535	1.475	1.687	1.635	1.614	1.560	6.857	6.787	6.372	6.292	6.945	6.875	6.724	5.56
T_4	1.637	1.587	1.587	1.527	1.690	1.640	1.638	1.584	7.082	7.005	6.487	6.407	7.127	7.052	6.898	5.82
T_5	1.550	1.500	1.435	1.376	1.587	1.542	1.524	1.472	6.790	6.720	6.292	6.212	6.837	6.767	6.639	6.56
F. test	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SE.m ±	0.0089	0.0090	0.0053	0.0056	0.0092	0.0087			0.0133	0.0138	0.0045	0.0051	0.0128	0.0131		
CD at 5%	0.0276	0.0276	0.0165	0.0174	0.0283	0.0269			0.0411	0.0426	0.0139	0.0158	0.0396	0.0405		

T_1 – Feeding 1st instar with S_{36} and remaining with M_5

T_2 – Feeding I and II instar with S_{36} and remaining with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

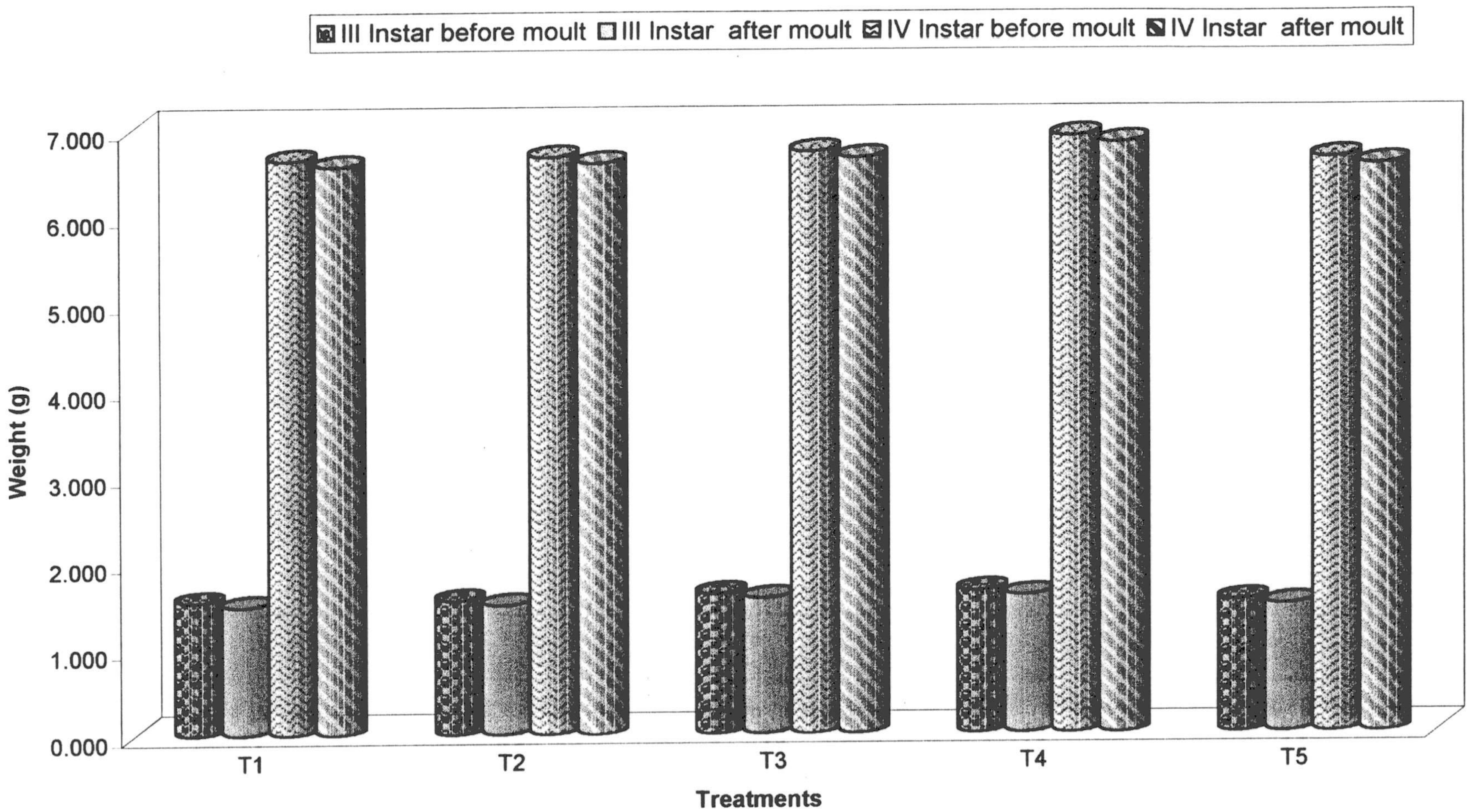

Fig. 2 Mean larval weight as influenced by S_{36} and M_5 mulberry leaves and their combinations

before moult. T_4 (6.821) recorded highest larval weight over the weight of T_3 (6.651) followed by T_2 (6.593), T_5 (6.566) and T_1 (6.562).

4.3.5 Larval weight at maturity

The data on mature silkworm (PM x NB_4D_2) weight as influenced by feeding leaves of S_{36} and M_5 mulberry variety grown under irrigated conditions are presented in Table V and Fig. 3.

In the first crop, there was significant differences in the weight of mature larvae on T_4 (30.06) when compared to T_3 (28.70). Neverthless, the weight of T_2 (28.66) was on par with T_1 (28.65) as well as T_5 (28.63).

In the second crop, weight of mature larvae was significantly higher in T_4 (28.95) when compared to T_3 (27.81). While T_2 (27.75) was on par with T_5 (27.71) as well as T_1 (27.71).

However, in the third crop, mature larval weight was significantly higher in T_4 (30.17) over the control of T_3 (28.95) followed by T_2 (29.76). Whereas, weight of T_2 (28.57) was on par with T_1 (28.53).

The mean of three crop, the ripened worm weight recorded maximum in T_4 (29.72) as compared to T_3 (28.48) followed by T_5 (28.36) and T_2 (28.32). The lowest mature larval weight was recorded in T_1 (28.29).

4.4 Effective rate of rearing (ERR)

The data on effective rate of rearing as influenced by feeding S_{36} and M_5 mulberry varieties grown under irrigated conditions are presented in Table V and Fig. 4.

Table V. Mature larval weight, ERR, total disease percentage as influenced by S_{36} and M_5 mulberry leaves and their combinations.

TREATMENTS	MATURE LARVAL WEIGHT (GMS)				EFFECTIVE RATE OF REARING (%)				TOTAL DISEASE PERCENTAGE (%)			
	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN
T_1	28.65	27.71	28.53	28.29	87.90	88.85	88.54	88.43	10.51	10.96	10.84	10.77
T_2	28.66	27.75	28.57	28.32	88.95	90.15	90.84	89.98	8.66	8.77	7.89	8.44
T_3	28.70	27.81	28.95	28.48	90.19	91.45	93.55	91.73	6.08	6.39	6.55	6.34
T_4	30.06	28.95	30.17	29.72	89.45	89.32	90.26	89.67	8.82	8.01	8.07	8.30
T_5	28.63	27.71	28.76	28.36	88.01	87.58	88.50	88.50	9.85	9.88	10.20	9.97
F. test	*	*	*		*	*	*		*	*	*	
SE.M ±	0.0169	0.0098	0.0272		0.2218	0.1392	0.1476		0.0062	0.0094	0.0078	
CD at 5%	0.0512	0.0303	0.0838		0.6835	0.1290	0.4548		0.0192	0.0291	0.0239	

T_1 – Feeding 1^{st} instar with S_{36} and remaining with M_5

T_2 – Feeding I and II instar with S_{36} and remaining with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

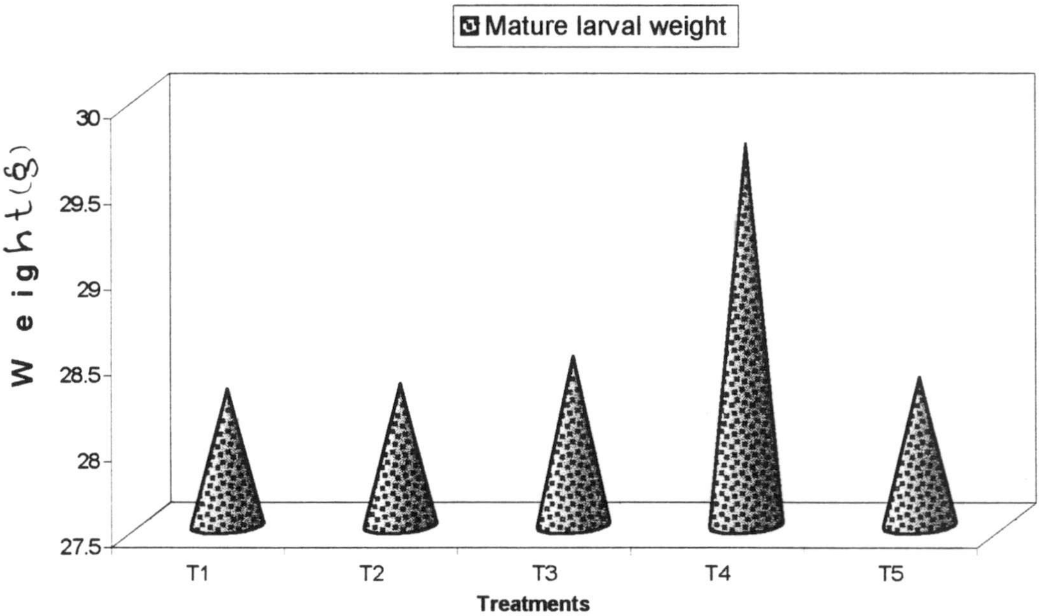

Fig. 3 Mean mature larval weight as influenced by S_{36} and M_5 mulberry leaves and their combinations

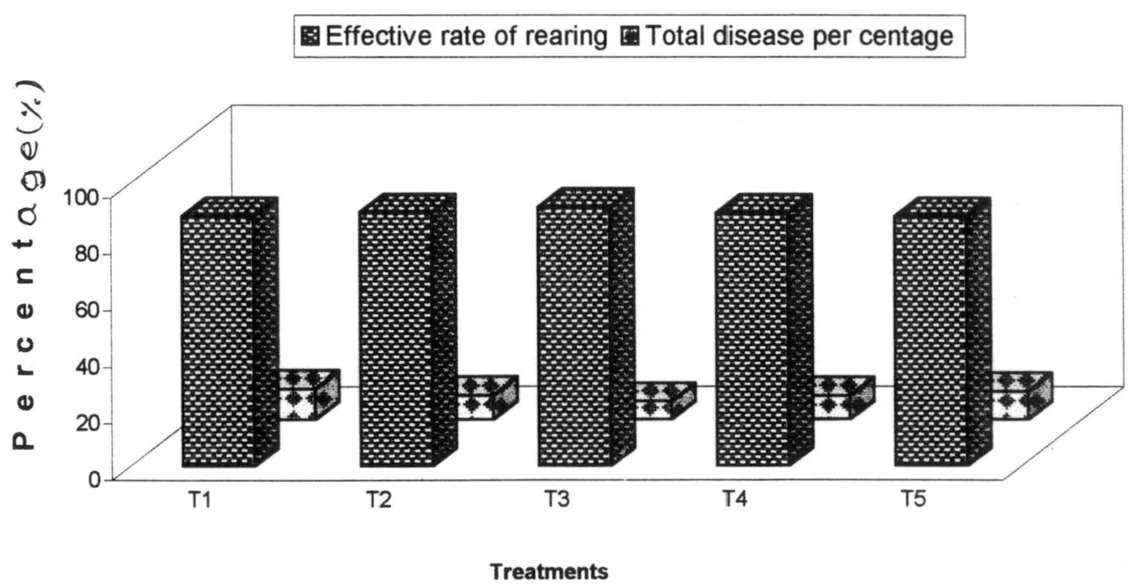

Fig.4 Mean effective rate of rearing and total disease per centage as influenced by S_{36} and M_5 mulberry leaves and their combinations

In the first crop, the percentage of ERR recorded significantly higher in T_3 (90.19) when compared to T_4 (89.45) followed by T_2 (88.95) and T_5 (88.01). The lowest ERR was recorded in T_1 (87.90).

In the second crop, the percentage of ERR was significantly higher in T_3 (91.45) over T_2 (90.15) followed by T_4 (89.32) and T_1 (88.35). The lowest ERR was in T_5 (87.58).

Further, in the third crop, there was significant treatmental differences. The percentage of ERR was significantly higher in T_3 (93.55) as compared to T_2 (90.84) followed by T_4 (90.26), T_1 (88.54) and T_5 (88.50).

However, the mean percentage of ERR recorded was maximum in T_3 (91.73) over the T_2 (89.98) and T_4 (89.67) followed by T_5 (88.50). Minimum of ERR was recorded in T_1 (88.43).

4.5 Disease incidence

The data on total disease incidence as influenced by feeding leaves of S_{36} and M_5 mulberry varieties grown under irrigated conditions are presented in Table V and Fig. 4.

In the first crop, the percentage of diseases were significantly differed among the treatments. T_3 (6.08) showed significantly minimum percentage of disease incidence when compared to T_1 (10.51) followed by T_5 (9.85) while T_4 (8.82) was on par with T_2 (8.66).

In the second crop, the disease percentage showed significant treatmental differences. T_3 (6.39) recorded very less disease incidence as compared to T_1 (10.96) followed by T_5 (9.88), T_2 (8.77) and T_4 (8.01).

Further in the third crop, T_3 (6.65) recorded minimum percentage of disease incidence when compared to T_1 (10.84) followed by T_5 (10.20), T_4 (8.07) and T_2 (7.89).

When averaged over three crops, the percentage of disease incidence was very less in T_3 (6.55) when compared to T_1 (10.77) and T_5 (9.97). However, T_4 (8.07) and T_2 (7.89) recorded slightly more over the control T_3 (6.34).

4.6 Commercial characters of cocoon

The commercial characters of cocoon like cocoon weight, pupal weight, shell weight, shell percentage, filament length, Denier and raw silk percentage are presented in Table VI, VII and Fig. 5,6. There was significant differences among the treatments with regard to the commercial characters as shown by statistical analysis.

4.6.1 Cocoon weight

The data on single cocoon weight as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented below.

In the first crop, there was significant differences in the weight of single cocoon on T_4 (1.519) as compared to T_3 (1.412) followed by T_5 (1.365) whereas T_2 (1.262) was on par with T_1 (1.228).

In the second crop, single cocoon weight recorded was significantly higher in T_4 (1.516) when compared to T_3 (1.393) followed by T_5 (1.308) and T_2 (1.252). Minimum was recorded in T_1 (1.208).

Further in the third crop, the single cocoon weight showed significant treatmental differences. T_4 (1.549) recorded significantly

Table VI. Weight of cocoons, weight of pupa, shell weight and shell percentage as influenced by S36 and M5 mulberry leaves and their combinations

Treatments	Weight of cocoons (gms)				Weight of pupa (gms)				Shell weight (gms)				Shell percentage (%)			
	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN
T_1	1.228	1.208	1.219	1.218	1.002	1.009	1.010	1.007	0.198	0.203	0.202	0.201	16.11	16.79	16.56	16.11
T_2	1.262	1.252	1.260	1.258	1.038	1.039	1.039	1.039	0.209	0.211	0.210	0.210	16.55	16.84	16.67	16.68
T_3	1.412	1.393	1.430	1.411	1.154	1.156	1.156	1.155	0.248	0.250	0.250	0.249	17.55	17.95	17.49	17.66
T_4	1.519	1.516	1.549	1.528	1.231	1.230	1.229	1.230	0.285	0.286	0.287	0.286	18.76	18.88	18.82	18.82
T_5	1.365	1.308	1.389	1.354	1.102	1.104	1.103	1.103	0.237	0.239	0.235	0.237	17.36	18.26	16.91	17.51
F. test	*	*	*		*	*	*		*	*	*		*	*	*	
SE.M ±	0.0151	0.0090	0.0112		0.0016	0.0010	0.0011		0.0007	0.0010	0.0013		0.1632	0.1553	0.1523	
CD at 5%	0.0479	0.0279	0.0346		0.0048	0.0030	0.0034		0.0020	0.0032	0.0041					

T_1 – Feeding 1st instar with S_{36} and remaining with M_5

T_2 – Feeding I and II instar with S_{36} and remaining with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

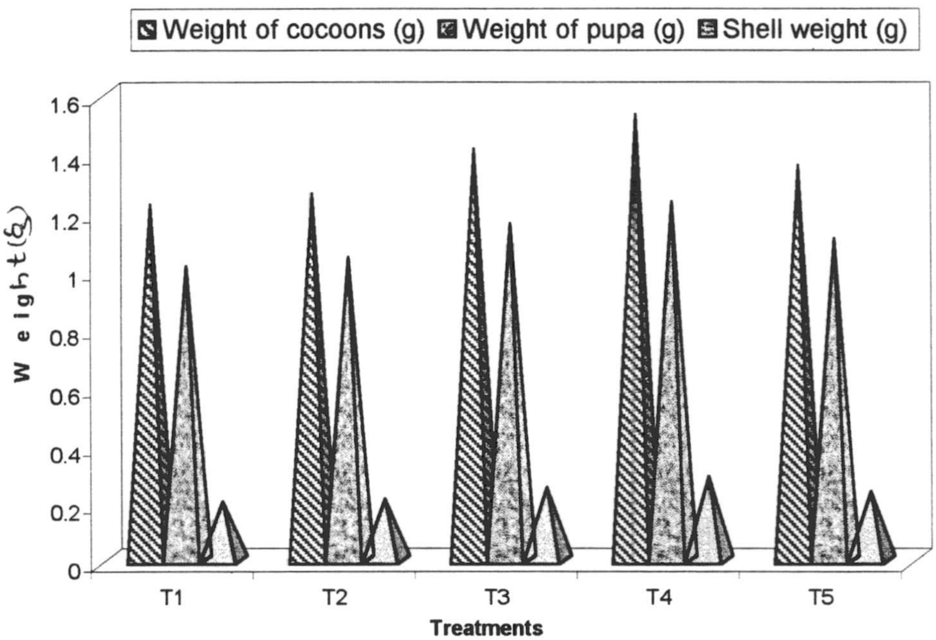

Fig. 5 Mean weight of cocoons, pupa and shell weight as influenced by S_{36} and M_5 mulberry leaves and their combinations

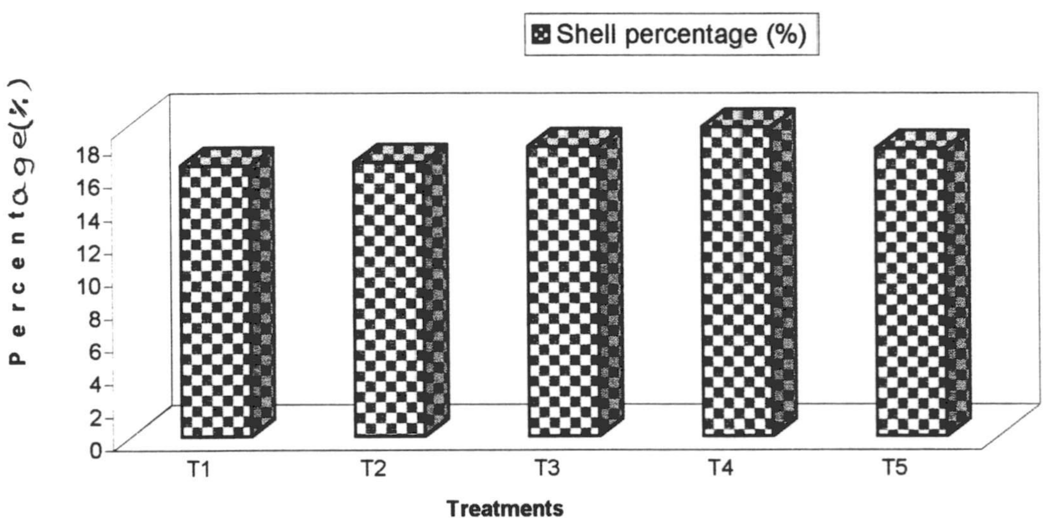

Fig.6 Mean shell percentage as influenced by S_{36} and M_5 mulberry leaves and their combinations

higher cocoon weight when compared to T_3 (1.430) followed by T_5 (1.389), T_2 (1.260) and T_1 (1.219).

However, the mean weight of single cocoon recorded was maximum in T_4 (1.528) as compared to T_3 (1.411) followed by T_5 (1.354) and T_2 (1.258), the lowest weight was recorded in T_1 (1.218).

4.6.2 Pupal weight

The data on single pupal weight as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented in Table VI and Fig. 5.

In the first crop, the pupal weight significantly differed among the treatments. T_4 (1.231) recorded significantly higher pupal weight over the control T_3 (1.154) followed by T_5 (1.102) T_2 (1.038) and T_1 (1.002).

In the second crop, T_4 (1.230) recorded significantly higher pupal weight when compared to T_3 (1.156) followed by T_5 (1.104) and T_2 (1.039). Lowest pupal weight was recorded in T_1 (1.009).

Further, in the third crop, there was significant treatmental differences. T_4 (1.229) showed significant higher pupal weight as compared to T_3 (1.156) followed by T_5 (1.103), T_2 (1.039) and T_1 (1.010).

When averaged over three crops, the maximum pupal weight was found in T_4 (1.230) compared to T_3 (1.155) followed by T_5 (1.103) and T_2 (1.039). The minimum pupal weight was recorded in T_1 (1.007).

4.6.3 Shell weight

The data on shell weight as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented below.

In the first crop, there was significant treatmental differences, T_4 (0.285) recorded significantly higher shell weight as compared to T_3 (0.248), T_5 (0.237) and T_2 (0.209). The lowest shell weight was recorded in T_1 (0.198).

In second crop T_4 (0.286) recorded significantly higher shell weight over the weight of T_3 (0.250) followed by T_5 (0.239). Neverthless, T_2 (0.211) was on par with T_1 (0.203).

However, in the third crop, the shell weight showed T_4 (0.287) recorded significantly higher shell weight as compared to T_3 (0.250) followed by T_5 (0.235). While T_2 (0.210) was on par with T_1 (0.202).

The mean weight of shell was maximum in T_4 (0.286) when compared to T_3 (0.249) followed by T_5 (0.237) and T_2 (0.210). The lowest shell weight was in T_1 (0.201).

4.6.4 Shell percentage

The data on shell percentage as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented Table VI and Fig. 6.

In the first crop, shell percentage was significantly higher in T_4 (18.76) as compared to T_3 (17.55) and T_5 (17.36) whereas T_2 (16.55) was on par with T_1 (16.11).

In the second crop, there was significant differences among the treatments. T_4 (18.88) recorded significantly higher shell percentage when compared to T_5 (18.26) followed by T_3 (17.95). Neverthless, the T_2 (16.84) was on par with T_1 (16.79).

Further, in the third crop, the shell percentage recorded was significantly higher in T_4 (18.82) over T_3 (17.49). Neverthless, the shell percentage of T_5 (16.91) was on par with T_2 (16.67) as well as T_1 (16.56).

When averaged over three crops, the shell percentage was maximum in T_4 (18.82) when compared to T_3 (17.66) followed by T_5 (17.51) and T_2 (16.68). The lowest shell percentage was recorded in T_1 (16.48).

4.6.5 Filament length

The data on filament length as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented in Table VII and Fig. 7.

In the first crop, length of the filament was significantly higher in T_4 (729.42) when compared to T_3 (694.88) where as T_2 (685.32) was on par with T_5 (684.80). T_1 (670.43) was recorded lowest filament length.

In second crop, there was significant treatmental differences recorded in this crop. T_4 (719.14) recorded significantly higher as compared to T_3 (691.58) followed by T_5 (680.63), T_2 (669.99) and T_1 (656.73).

However, in the third crop, T_4 (733.20) recorded significantly higher over T_3 (694.55) followed by T_5 (682.55) and T_2 (679.64) whereas T_1 (671.40) recorded lowest filament length.

Table VII. Filament length, denier and raw silk percentage as influenced by S_{36} and M_5 mulberry leaves and their combinations

TREATMENTS	FILAMENT LENGTH (mts)				DENIER				RAW SILK PERCENTAGE (%)			
	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN	I-CROP	II-CROP	III-CROP	MEAN
T_1	670.43	656.73	671.40	666.18	2.27	2.13	2.28	2.29	84.96	85.08	85.51	85.18
T_2	685.32	669.99	679.64	678.31	2.27	2.30	2.30	2.29	85.40	86.01	85.96	85.79
T_3	694.88	691.58	694.55	693.67	2.27	2.27	2.26	2.26	87.79	87.99	88.60	88.13
T_4	729.42	719.14	733.22	727.26	2.22	2.23	2.23	2.23	89.38	89.69	89.36	89.47
T_5	684.80	680.63	682.55	682.66	2.31	2.28	2.27	2.29	86.80	87.44	87.01	87.08
F. test	*	*	*		*	*	*		*	*	*	
SE.M ±	1.0683	0.9654	0.8336		0.0059	0.0115	0.0067		0.1937	0.4567	0.2687	
CD at 5%	3.2919	2.9748	2.5689		0.0183	0.0354	0.0206		0.5968	1.4073	0.8279	

T_1 – Feeding 1st instar with S_{36} and remaining with M_5

T_2 – Feeding I and II instar with S_{36} and remaining with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

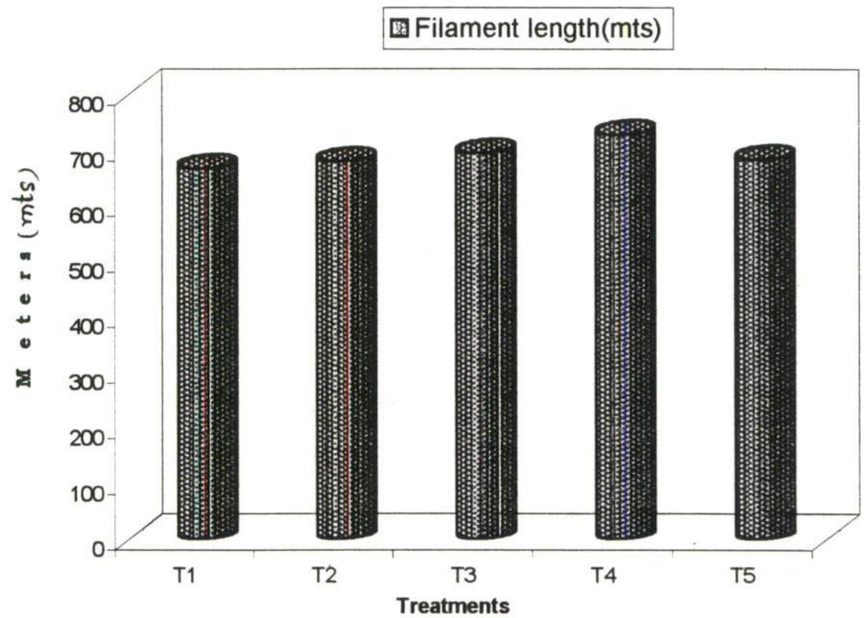

Fig.7 Mean filament length as influenced by S_{36} and M_5 mulberry leaves and their combinations

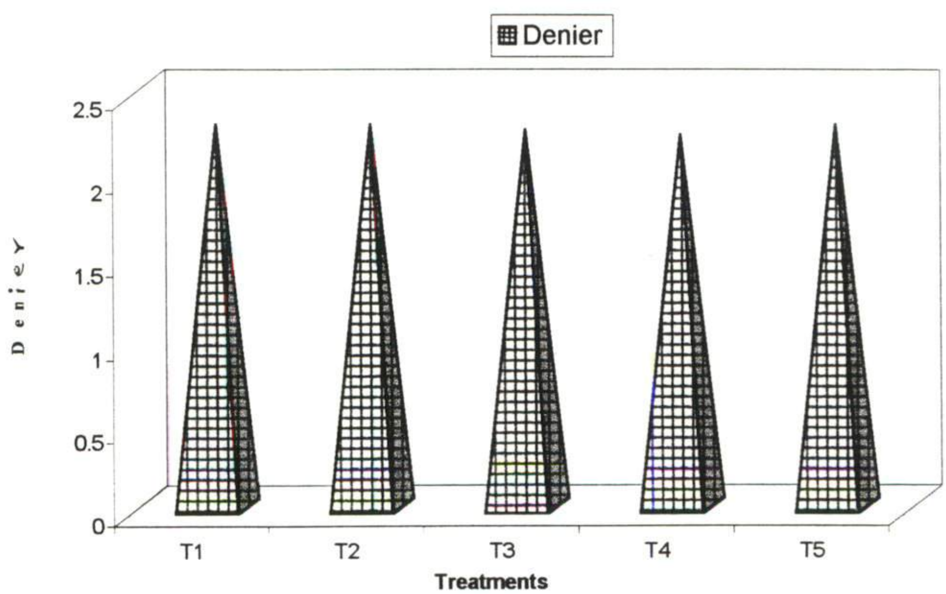

Fig.8 Mean Denier as influenced by S_{36} and M_5 mulberry leaves and their combinations

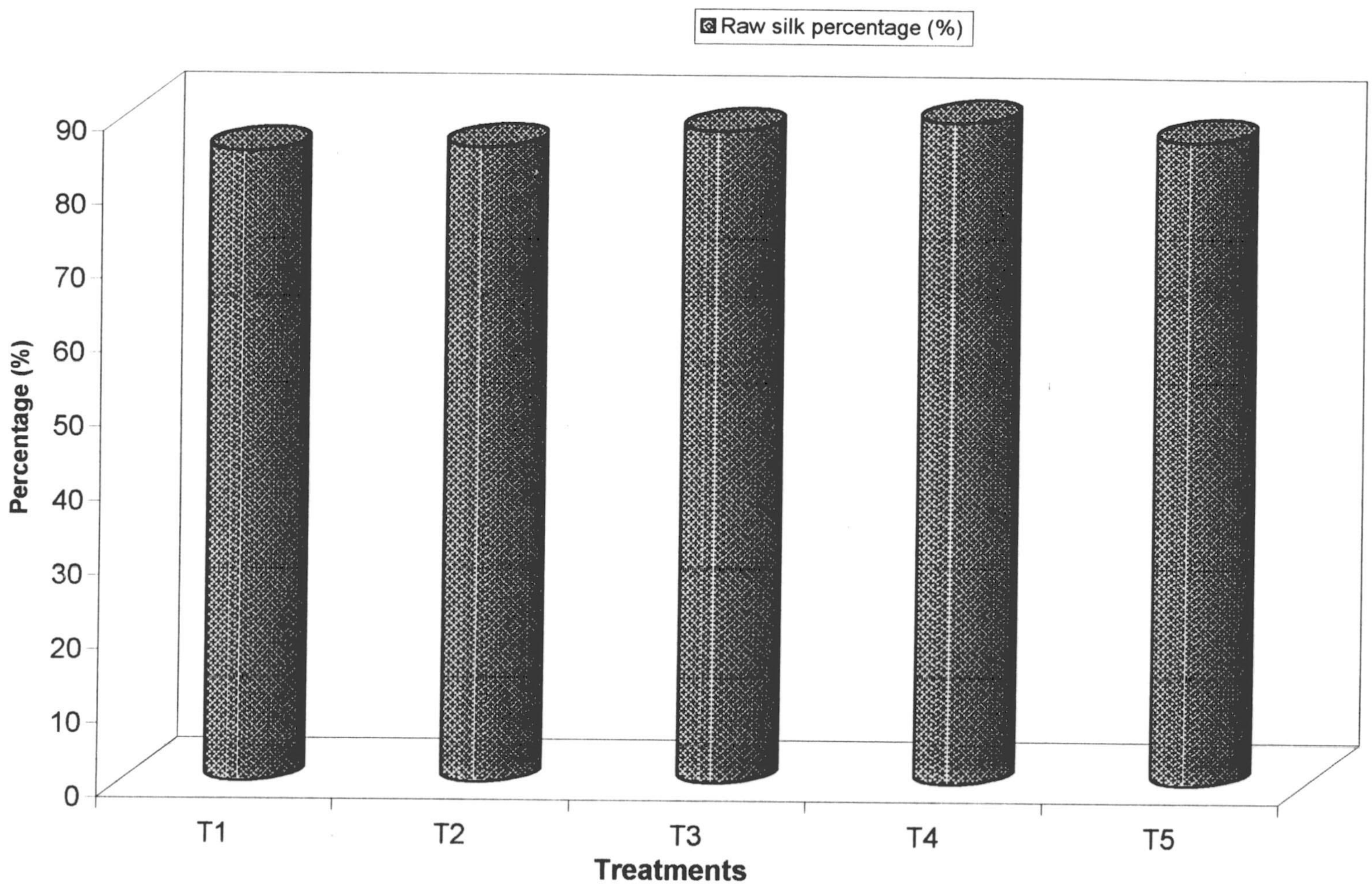

Fig. 9 Mean Raw silk percentage as influenced by S_{36} and M_5 mulberry leaves and their combinations

When averaged over the crops, length of the filament was maximum in T_4 (727.26) as compared to T_3 (693.67) followed by T_5 (682.66) and T_2 (678.31) while T_1 (666.18) was recorded lowest filament length.

4.6.6 Denier

The data on Denier as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented in Table VII and Fig. 8.

In the first crop, the Denier was significantly higher in T_5 (2.31) when compared to T_4 (2.22) followed by T_1 (2.27), T_2 (2.27) and T_3 (2.27).

In the second crop, there was significantly higher Denier in T_1 (2.31) as compared to T_4 (2.23). Neverthless T_2 (2.30) was on par with T_5 (2.28) as well as T_3 (2.27).

Further, in the third crop, the Denier recorded was significantly higher in T_2 (2.30) and T_1 (2.28) when compared to T_4 (2.23) whereas, T_5 (2.27) was on par with T_3 (2.26).

When averaged over three crops, the Denier recorded was maximum in T_1 (2.29), T_2 (2.29) and T_5 (2.29) when compared to T_4 (2.23) followed by T_3 (2.26).

4.6.7 Raw silk percentage

The data on raw silk percentage as influenced by feeding leaves of S_{36} and M_5 mulberry varieties are presented in Table VII and Fig. 9.

In the first crop the raw silk percentage recorded was significantly higher in T_4 (89.38) when compared to T_3 (87.79) whereas, T_5 (86.80) T_2 (85.40) and T_1 (84.96) recorded significantly lowest raw silk percentage.

In second crop, significant difference was found among the treatments. T_4 (89.69) recorded significantly higher raw silk percentage as compared to T_3 (87.99). Neverthless, T_5 (87.44) was on par with T_2 (86.01). The lowest raw silk percentage was found in T_1 (85.08).

However, in the third crop, the percentage of raw silk recorded was significantly higher in T_4 (89.36) as compared to T_3 (88.60) followed by T_5 (87.01) whereas T_2 (85.96) was on par with T_1 (85.51).

Mean percentage of raw silk recorded was maximum in T_4 (89.47) when compared to T_3 (88.13) followed by T_5 (87.08) and T_2 (85.79) whereas, T_1 (85.18) recorded lowest raw silk.

4.6.8 Disease incidence on silkworm

The percentage of different disease incidence on silkworm recorded during the crop growth period is presented in Table VIII and Fig. 10.

4.7.1 Incidence of pebrine disease

The pebrine disease incidence was absolutely zero in all the three crops.

4.7.2 Incidence of muscardine disease

In the first crop, the percentage of muscardine disease was significantly lowest in T_4 (3.02) when compared to T_1 (4.68), T_5 (4.01), T_2 (3.86) and T_3 (3.09).

Table VIII : Muscardine, flacherie and grassarie disease as influenced by S_{36} and M_5 mulberry leaves and their combinations.

Treatments	Muscardine				Flacherie				Grassarie			
	I CROP	II CROP	III CROP	MEAN	I CROP	II CROP	III CROP	MEAN	I CROP	II CROP	III CROP	MEAN
T_1	4.68	4.98	4.89	4.85	3.18	3.27	3.21	3.22	2.65	2.71	2.74	2.70
T_2	3.86	3.96	3.04	3.62	2.68	2.55	2.57	2.60	2.12	2.26	2.28	2.22
T_3	3.09	3.21	3.36	3.15	1.32	1.39	1.34	1.35	1.67	1.79	1.85	1.77
T_4	3.02	3.10	3.09	3.07	1.60	1.61	1.72	1.64	4.20	3.30	3.26	3.58
T_5	4.01	3.98	4.46	4.15	3.15	3.19	3.18	3.17	2.69	2.71	2.55	2.65
F-test	*	*	*	-	*	*	*	-	NS	NS	NS	-
S.Em ±	0.0141	0.0123	0.0101	-	0.0063	0.0072	0.0104	-	0.0070	0.0077	0.0075	-
CD at 5%	0.0434	0.0378	0.0311	-	0.0195	0.221	0.0321	-	-	-	-	-

T_1 – Feeding 1st instar with S_{36} and remaining with M_5

T_2 – Feeding I and II instar with S_{36} and remaining with M_5

T_3 – Feeding first 3 instar with S_{36} and remaining with M_5

T_4 – Feeding S_{36} throughout

T_5 – Feeding M_5 throughout

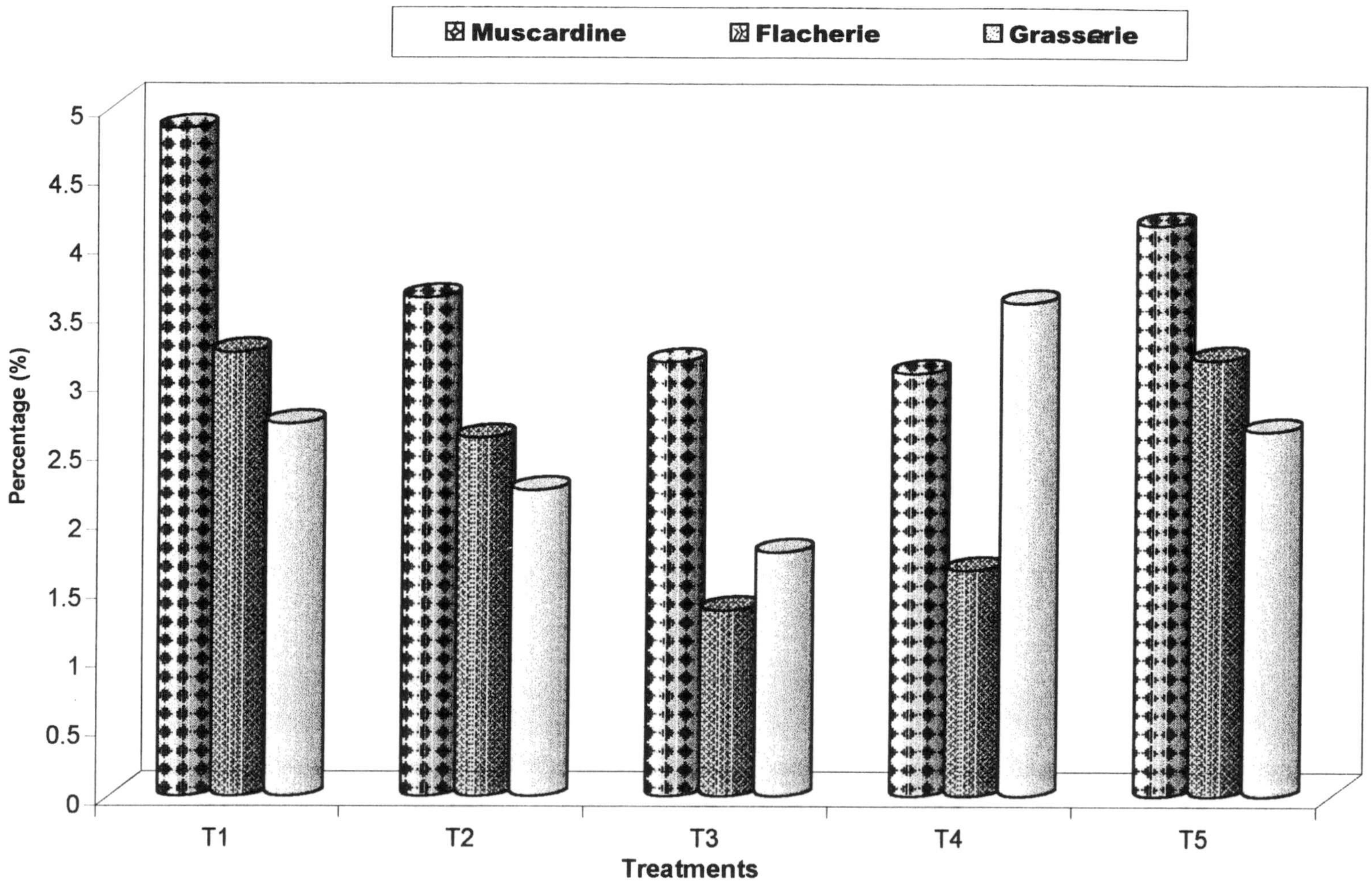

Fig. 10 Mean percentage of Muscardine, Flacherie and Grassarie diseases as influenced by S_{36} and M_5 mulberry leaves and their combinations

In second crop, there was significant difference among the treatments. The percentage of muscardine disease recorded was significantly lowest in T_4 (3.10) as compared to T_1 (4.98). Whereas, T_5 (3.98) was on par with T_2 (3.96) followed by T_3 (3.21).

Further, in the third crop, all the treatments showed significant differences. T_4 (3.09) recorded significantly lowest incidence of muscardine diseases when compared to T_1 (4.89) followed by T_5 (4.46), T_3 (3.36) and T_2 (3.04).

When averaged over crops, the incidence of muscardine diseases was minimum in T_4 (3.07) as compared to T_1 (4.85) which recorded maximum muscardine disease incidence. However T_4 (4.15) T_2 (3.62) and T_3 (3.15) were followed by T_1 (4.85).

4.7.3 Incidence of Flacherie disease

In the first crop, there was significantly minimum percentage of flacherie disease incidence in T_3 (1.32) and T_4 (1.60) as compared to T_1 (3.18) followed by T_5 (3.15) and T_2 (2.68).

In second crop, the percentage of flacherie disease incidence was significantly lowest in T_3 (1.39) and T_4 (1.61) when compared to T_1 (3.27) followed by T_5 (3.19) and T_2 (2.55).

Further, in the third crop, the flacherie disease incidence was significantly lowest in T_3 (1.34) and T_4 (1.72) as compared to T_1 (3.21), T_5 (3.18) and T_2 (2.57).

The mean percentage of these crops, the minimum flacherie disease incidence were found in T_3 (1.35) and T_4 (1.64) when compared to T_1 (3.22) followed by T_5 (3.17) and T_2 (2.60).

4.7.4 Incidence of Grasserie disease

In the first crop, the incidence of Grasserie disease recorded was significantly highest in T_4 (4.20) when compared to T_3 (1.67). whereas T_5 (2.69), T_1 (2.65) and T_2 (2.12) recorded significantly highest Grassarie disease incidence.

In second crop, T_4 (3.30) recorded significantly highest incidence as compared to T_3 (1.79) while T_1 (2.71) and T_5 (2.71) recorded equal percentage followed by T_2 (2.26).

Further, in the third crop, T_4 (3.26) was recorded significantly higher incidence when compared to T_3 (1.85). However T_1 (2.74) T_5 (2.55) and T_2 (2.28) were recorded significantly lowest disease incidence.

When averaged over these crops, the percentage of grassarie disease incidence was maximum in T_4 (3.58) followed by T_1 (2.70), T_3 (2.65) and T_2 (2.2) the lowest incidence was recorded in T_3 (1.77).

DISCUSSION

V. DISCUSSION

The major objective of the present investigations was to evaluate the "Influence of S_{36} mulberry variety on the rearing performance of the silkworm" the nutritional status of S_{36} mulberry variety and their effect on larval growth, cocoon characters and silk quality on PM x NB_4D_2 have been discussed here in the light of earlier studies.

There were several investigations carried out to screen improved varieties of mulberry to assess their quality and quantity of leaves in order to obtain better profit from silkworm rearing. But investigation on feeding only S_{36} mulberry leaves in all the stages and their effect on silkworm growth, cocoon characters and silk quality are scanty. The results obtained in the experiments are discussed under the following headings.

5.1 Nutritional status as influenced by S_{36} mulberry variety

5.2 Micro-climate changes as influenced by S_{36} mulberry variety

5.3.1 Influence of S_{36} mulberry variety on chawki worm weight.

5.3.2 Influence of S_{36} mulberry variety on late-age worm weight

5.4 Influence of S_{36} mulberry variety on ERR and total disease incidence

5.5.1 Influence of S_{36} mulberry variety on cocoon characters and silk quality

5.5.2 Influence of S_{36} mulberry variety on shell percentage, filament length, denier and raw silk percentage

5.6 Influence of S_{36} variety on disease incidence.

5.1 Nutritional status

In the present study, Moisture per cent of leaves varied with the matured leaves. The tender leaves had more moisture followed by mature leaves. In tender leaves moisture percentage recorded was maximum in S_{36} (74.51) followed by M_5 (73.71) leaves. In mature leaves, S_{36} recorded more moisture percentage (69.81) than M_5 (65.42). Similar results have been reported by Friend (1958) and Wald bauer (1968) also high lighted the importance of dietary moisture content and reported that phytophagous insects require high water intake for normal development and feeding of leaves with wilted foliage produced adverse effects. According to Ito (1963) higher leaf moisture was known to increase the amount of leaf ingestion and digestion capacity of silkworm through its olfactary and gustatory simulative effect. While Sengupta *et al.* (1971) observed that low leaf moisture affect the growth and development of silk worms.

Mulberry leaf protein is the chief source of silkworm for the biosynthesis of silk. The variety which is rich in the protein content will be better for silkworm rearing. In tender leaves, the variety S_{36} recorded maximum crude protein of 23.93. Where as M_5 recorded minimum crude protein of 22.85. In mature leaves, the highest crude protein was recorded in S_{36} (20.91) than M_5 (18.92). The results are supported by Rangaswami *et al.* (1976) where they observed that the crude protein decreased from tender leaves to matured leaves. Li and Sang (1984) and Sreedhara *et al.* (1988) reported that, low level of protein and water content did not favour the optimal growth in *B. mori*. Bongale *et al.*, (1991) and Chaluvachari and Bongale (1996) observed that high protein content in top tender leaves which are nutritionally richer compared to medium and mature leaves and these were of special significance with respect to larval weight and molting ratio of young age larvae.

Total sugars of leaves varied from tender to mature leaves in tender leaves. Higher percentage of total soluble sugars was found in M_5 (12.50) leaves. Lowest was recorded in S_{36} (11.31). In mature leaves, M_5 (9.53) recorded maximum. While S_{36} (7.38) recorded minimum. Similar observations were made by Ratna Sen *et al.* (1991) who reported a significant increase in soluble sugar content in tender and medium leaf of high stem pruning as compared to basal pruning. Bose *et al.* (1991) reported that variety S_{36} recorded high reducing sugar (1.56), non-reducing sugar (11.31) and total sugars (11.31). Chaluvachari and Bongale (1996) observed that higher sugar, moisture and protein content had significant effect on larval growth, development and moulting ratio of young age silkworms.

The chlorophyll "a" was maximum in both tender (1.70) and mature leaves (1.82) of S_{36} variety followed by tender (1.36) and mature leaves (1.66) of M_5. The chlorophyll 'b' was maximum in both tender leaves (0.91) and matured leaves (0.84) of S_{36} variety followed by tender (0.82) and matured leaves (0.79) of M_5.

The total chlorophyll content was highest in S_{36} variety in both tender (2.61) and mature leaves (2.66) followed by tender (2.180) and mature leaves (2.450) of M_5 variety. In general, the chlorophyll contents were higher in mature leaves than tender leaves. Viswanath (1979) reported that chlorophyll content increases as the maturity of leaf advances. He recorded 1.614, 2.121 and 2.342 mg/g in top medium and coarse leaves respectively.

The crude fibre content increased as the maturity of leaves increased, the crude fiber was maximum in both tender (9.10) and mature leaves (12.73)of S_{36} variety followed by 8.52 per cent in tender and 11.40 per cent in matured leaves of M_5. Similar findings made by Lokanath (1980) where he recorded 7.898, 9.670 and 11.944 per cent in top, middle and bottom leaves. However, the mean maximum crude fibre was in S_{36} (9.33%) followed by S_{54} (9.23%).

The carbohydrate content increased in mature leaves than the tender leaves. The carbohydrate percentage was maximum in both tender (18.12) and mature leaves (23.00) of S_{36} variety followed by tender (16.99) and mature leaves (21.31) of M_5 variety. The result are supported by Dale (1985) and Bieleski and Redgwell (1985) who reported that mature leaf rapidly translocates carbohydrates to the younger leaves. Increase in carbohydrate content in tender and medium leaf of high stem prunning slowed by the process of translocation of carbohydrates from mature leaf to younger leaf might have accelerated. A study by Bose *et al.* (1991) showed that S_{36} as the most nutritive compared to Local, Kanva-2, S_{30}, S_{41} and S_{54}. Further they stated that S_{36} recorded maximum total carbohydrates (21.31%) in addition to other nutritional parameters.

5.2 Micro-climate changes as influenced by S_{36} mulberry variety

Environmental conditions like temperature, relative humidity, air and light from hatching to cocooning have an intimate relationship on the growth of silkworm and on the quality of cocoons. The mean microclimate data were recorded during January, February, May, June and July. The maximum temperature ranged from 19.00–21.33^{0}C and minimum temperature ranged from 18.00-19.33. Where as, the maximum relative humidity ranged from 76.33 – 84.00 percentage and minimum R.H. ranged from 62.00–74.00 per cent.

The mean rearing room weather data indicated that maximum temperature ranged from 19.66 – 21.66^{0}C and minimum temperature ranged from 18.66 – 20.33^{0}C whereas the maximum relative humidity ranged from 77.00 – 83.66 percentage and minimum RH ranged from 67.00 – 77.66 per cent.

When compared, micro-climate and room weather data the micro-climate data slightly decreased in rearing trays compared to room weather data like wise, room weather data slightly increased over micro-climate. From this we can say, by feeding S_{36} mulberry variety to silkworms it can slightly decrease the temperature and increase the relative humidity in the rearing bed because S_{36} variety contains more moisture than the other mulberry varieties. The S_{36} variety gives good support to silkworm by its nutritional quality by regulating environmental conditions.

5.3.1. Influence of S_{36} mulberry variety on chawki worms weight

The mean of three rearings indicated that the chawki worms weight before and after first moult showed non-significant difference among the treatments. The chawki worm weight ranged from 0.054 to 0.055g before moult. Whereas, chawki worm weight after moult ranged from 0.052 to 0.053. The chawki worms weight before and after second moult recorded significant treatmental differences. The weight in T_3 (0.273) and T_4 (0.273) chawki worms was significantly highest followed by T_2 (0.268) before moult. However, the chawki worm weight after moult, T_4 (0.270) recorded more weight than T_3 (0.269) followed by T_2 (0.264). Further, the chawki worms weight before and after third moult recorded maximum weight in T_4 (1.638) followed by T_3 (1.614) before moult. Where as, the chawki worms weight after third moult, T_4 (1.584) produced more weight compared to T_3 (1.560). In general, the T_4 (feeding S_{36} leaves throughout the instar) was found to be best for chawki worms rearing. T_4 recorded significantly superior results than T_3, T_2, T_1 and T_5. This was due to the variety S_{36} leaves, which had more moisture, crude protein, soluble sugars, less crude fibre and less carbohydrates than the M_5 leaves. The results are in close agreement with the work of Anonymous (1983 a), Mala *et al.* (1992) on the quality of S_{36} and S_{30} which are comparatively better than K_2, S_{41} and S_{54}.

5.3.2 Influence of S_{36} mulberry variety on late-age worms weight

When averaged over three crops, the late-age worm weight before and after fourth moult gave significant differences among treatments. The late-age worms weight of T_4 (6.898) produced maximum weight than T_3 (6.724) followed by T_2 (6.667) before moult and after fourth moult. The T_4 (6.921) recorded highest weight compared to T_3 (6.651) followed by T_2 (6.593). Further, at mature stage, the maximum weight was recorded in T_4 (29.72) compared to T_3 (28.48). In general, the T_4 (feeding S_{36} mulberry leaves throughout the instar) performed well in each crop and gave superior results compared to T_3, T_2, T_1 and T_5. Earlier studies conducted by Singh *et al.* (1976) on S_{30} and S_{36} gave better mature larval weight of 33.88 gms and 33.80 gm/10 worms respectively. According to Venkataramu (1986) S_{54} and S_{36} produced better larval weight of 29.63 g and 26.24 g per 10 worms respectively. Bheemanna *et al.* (1989) opined that feeding NB_7 and NB_{18} race with S_{36} leaves resulted in maximum progression of the 4^{th} instar. In the same line Mallikarjunappa *et al.* (1992) evaluated S_{30}, S_{36} and Viswa. The data indicated that S_{36} gave maximum larval weight (31.67 g).

5.4 Influence of S_{36} mulberry variety on ERR and Disease incidence

The mean values of three crops, indicated that percentage of effective rate of rearing recorded was maximum in T_3 (91.73) compared to T_2 (89.98) followed by T_4 (89.67). However, the disease percentage recorded was highest in T_1 (10.77) compared to T_4 (8.30) while T_3 (6.34) recorded lowest disease percentage compared to T_4 (8.30), T_2 (8.44), T_5 (9.97) and T_1 (10.77). According to Das and Vijayraghavan (1990) indicated that ERR was 7573/10,000 worms. A study by Giridhar *et al.* (1991) showed that S_{36} recorded highest ERR (9250/10000 worms). In a similar trend, Mallikarjunappa *et al.* (1992) have reported that the variety S_{36} gave maximum ERR (8609/10000 worms) while Satish (1984) noticed that the disease incidenc recorded was maximum (10.44%) during June-July. According to Subba rao *et al.* (1991) the total loss due to different disease ranged from 0.58 to 4.18. Clearly indicated that the quality of mulberry leaf, rearing technique used and daily proper vigilance are most important for harvest of cocoons and also control of disease incidences

5.5.1 Influence of S_{36} mulberry variety on cocoon characters and silk quality

The mean cocoon weight, pupal weight, shell weight and silk quality were much affected by feeding silkworms on S_{36} mulberry variety. The S_{36} variety showed significant differences in cocoon characters and silk quality. This may due to the nutritive status in the leaves of S_{36} so as to produce significant differences. In this investigation, the T_4 recorded highest cocoon weight (1.528) compared to T_3 (1.411) followed by T_5 (1.354). Whereas, the pupal weight was maximum in T_4 (1.230) compared to T_3 (1.155) followed by T_5 (1.103). However, weight of the shell was highest in T_4 (0.286) compared to T_3 (0.249) followed by T_5 (0.237). In general the T_4 gave significant results at each crop and performed better than that of T_3, T_5, T_2 and T_5. These results are supported by Singh *et al.* (1976) who reported single cocoon weight 1.420 g on S_{30} and 1.360g on S_{36} leaves. Govindan *et al.* (1987) have reported that, the variety S_{41} and S_{36} gave higher cocoon weights (2.120 g) and (1.881 g) respectively. A study by Das *et al.* (1990) observed that the variety S_{36} recorded highest single cocoon weight (1.320) and single shell weight (0.200 g). According to Venkataramu (1986) S_{36} variety showed higher single cocoon weight (1.638), pupal weight (1.387) and shell weight (0.276). similarly Mallikarjunappa *et al.* (1992) have reported that S_{36} variety gave single cocoon weight (1.903) and single shell weight (0.400g)

5.5.2 Shell percentage, filament length, Denier and raw silk percentage

When averaged over three crops, the shell percentage was higher in T_4 (18.82) compared to T_3 (17.66) followed by T_5 (17.51). This might be due to the fact that silkworms had greater ability to convert the ingested leaf of S_{36} variety to silk synthesis than other body matters when compared to ingestion of M_5. However, the filament length (m) recorded was maximum in T_4 (727.26) as compared to T_3 (693.67) followed by T_5 (682.66). These results are supported by earlier studies of Das *et al.* (1990) who opined that S_{36} recorded 17.53 per cent of shell percentage. In a similar study, Venkataramu (1986) reported that S_{54} and S_{36} recorded higher shell percentage of 16.82 and 16.32 respectively. A study by Bheemanna *et al.* (1997) have also broughtout the fact that Improved varieties viz., S_{30}, S_{36}, S_{41} and S_{54} performed well on the bivoltine breeds, the shell percentage was maximum when reared on S_{36}, S_{30} and S_{41} (22.67-31.30). While single cocoon filament length was highest in S_{54}, S_{36} and S_{41} (1133-1200 m). It clearly indicates that the quality of leaf is one of the important parameters, which determines the performance of silkworm during their development and spinning quality cocoons.

Minimum Denier was recorded in T_4 (2.23) compared to T_1 (2.29), T_2 (2.29), T_5 (2.29) and T_3 (2.26). However, the raw silk percentage recorded was maximum in T_4 (89.47) compared to T_3 (88.13) followed by T_5 (87.08)

5.6 Influence of S_{36} mulberry variety on muscardine, flacherie and grasserie.

The mean of three crops indicated that percentage of muscardine recorded was lowest in T_4 (3.07). The highest percentage recorded was in T_1 (4.85) followed by T_5 (4.15), T_2 (3.62) and T_3 (3.15). Where as, the percentage of flacherie disease was minimum in T_4 (1.64). The maximum was recorded in T_1 (3.22) followed by T_5 (3.17), T_2 (2.60) and T_3 (1.35). However, percentage of grassarie incidence was higher in T_4 (3.58) and minimum was recorded in T_3 (1.77). The results are supported by studies of Janakiraman (1961) who reported that the chief diseases affecting the mulberry silkworms are flacherie, muscardine, grassarie and pebrine. Of which, flacherie is in more proportion. A study by Sidhu and Singh (1968) estimated the crop loss of 30-40 per cent due to viral disease. The incidence of diseases like grasserie and flacherie was highest during may to July (Anon., 1979). However, Kolar (1995) opined that the Dec-Jan rearing was most favorable season, that resulted in lower incidence of natural enemies like muscardine (7.55%), grasserie (3.64%) and flacherie (2.22%). These results are in close argument on the present study, it indicated that flacherie and grasserie are more common diseases affecting the mulberry silkworm. Hence, quality of mulberry leaf, rearing technique and environmental conditions are pre-requisite for harvest of good crop.

SUMMARY

VI. SUMMARY

The studies carried out on the "Influence of S_{36} mulberry variety on the rearing performance of mulberry silkworm *Bombyx mori*" was carried out with two mulberry varieties viz., S_{36} and $M_{5.}$ grown under irrigated conditions to find out the nutritional quality of leaf and its effect on the larval growth and cocoon parameters have been summarised below.

The results of bio-chemical analysis revealed that the improved variety S_{36} had higher chemical constituents than the M_5 mulberry variety. The variety S_{36} recorded highest moisture percentage (72.16%), crude protein (22.42%) less amount of total soluble sugars (9.34) followed by M_5 variety. The S_{36} mulberry variety had maximum amount of total chlorophyll content (2.63mg), maximum amount of crude fibre [10.91%] and carbohydrates [20.56%]. The variety S_{36} gave maximum larval weight before and after moult from first to fifth instar. The variety S_{36} recorded low effective rate of rearing (89.67%) compared to control T_3 (91.73%). The percentage of disease incidence recorded was more in S_{36} (8.30) compared to control T_3 (6.34).

Significant difference was found in the cocoon characters and silk qualities when fed on S_{36} mulberry variety. The S_{36} variety recorded maximum cocoon weight (1.528g), pupal weight (1.230g), shell weight (0.286g) shell percentage (18.82%) filament length (727.26mts) and raw silk percentage (89.47%) and significantly lower Denier (2.23). Whereas, incidence of muscardine (3.07%) and flacherie (1.64%) recorded was minimum, while the grassarie incidence was maximum (3.58%) among the worms reared in S_{36} mulberry variety.

Hence, it can be concluded that the mulberry variety S_{36} has performed better with respect to nutrient status of leaf and silkworm parameters compared to M_5 mulberry variety. Therefore, the mulberry variety S_{36} supported better larval growth, cocoon characters and silk quality. The M_5 mulberry variety did not recorded maximum leaf chemical constituents which may be the reason for its poor performance with regard to larval growth, cocoon characters and silk quality.

Based on these investigations, the S_{36} mulberry variety can suitably be used throughout the instars than the recommended practice of S_{36} for chawki worms and M_5 for late age worms. Though slightly more susceptible for grassarie diseases, it gave good cocoon yield. Therefore, S_{36} mulberry variety can be recommended for feeding the silkworm in all the instars with proper environmental conditions.

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APPENDICES

Appendix – I Temperature and Relative humidity recorded in the rearing room at MRS, Hebbal, Bangalore during first rearing

Date	Room temperature												
	Morning		Afternoon		Evening			Morning		Afternoon		Evening	
	Temp	RH	Temp	RH	Temp	RH	Date	Temp	RH	Temp	RH	Temp	RH
1-1-99	19	79	22	71	20	79	18-1-99	21	70	22	67	19	79
2-1-99	19	79	22	67	20	79	19-1-99	20	74	21	70	19	79
3-1-99	18	83	21	71	19	69	20-1-99	20	74	21	79	20	74
4-1-99	19	79	23	68	20	79	21-9-99	20	74	22	71	19	79
5-1-99	18	83	23	68	20	74	22-1-99	21	70	22	67	20	64
6-1-99	19	83	21	70	19	79	23-1-99	20	74	21	75	19	79
7-1-99	20	79	22	67	20	74	24-1-99	20	74	21	70	19	79
8-1-99	20	79	22	67	20	74	25-1-99	21	70	22	71	20	74
9-1-99	20	79	21	75	19	79	26-1-99	20	74	21	71	19	79
10-1-99	20	79	22	67	20	79	27-1-99	20	74	21	70	19	79
11-1-99	20	74	22	69	19	83	28-1-99	21	75	22	67	21	75
12-1-99	19	79	21	70	18	83	29-1-99	19	89	20	75	21	70
13-1-99	19	79	20	74	19	79	30-1-99	20	89	21	70	21	70
14-1-99	20	74	22	71	19	79	1-2-99	20	89	21	70	20	74
15-1-99	19	79	21	70	18	83							
16-1-99	20	74	22	67	20	74							

Appendix – II Temperature and Relative humidity recorded in the rearing room at MRS, Hebbal, Bangalore during second rearing.

Date	Room temperature												
	Morning		Afternoon		Evening			Morning		Afternoon		Evening	
	Temp	RH	Temp	RH	Temp	RH	Date	Temp	RH	Temp	RH	Temp	RH
21-5-99	21	70	23	68	19	69	7-6-99	21	70	22	71	19	79
22-5-99	21	70	22	71	19	69	8-6-99	21	70	22	71	19	79
23-5-99	20	74	22	71	20	79	9-6-99	21	70	22	67	19	69
24-5-99	20	89	22	67	19	79	10-6-99	20	74	22	71	18	83
25-5-99	19	79	21	70	19	69	11-6-99	19	79	21	75	19	69
26-5-99	19	79	21	71	18	83	12-6-99	19	79	22	71	19	79
27-5-99	20	74	21	71	19	69	13-6-99	18	83	21	75	18	83
28-5-99	21	75	22	67	20	74	14-6-99	20	74	22	71	19	79
29-5-99	20	74	22	67	18	83	15-6-99	21	70	22	71	19	69
30-5-99	21	70	23	68	19	69	16-6-99	19	79	21	75	19	69
31-5-99	21	70	22	71	18	83	17-6-99	18	83	21	75	19	69
1-6-99	21	70	22	67	19	79	18-6-99	20	74	22	72	19	69
2-6-99	21	70	22	67	19	79	19-6-99	20	74	22	71	19	69
3-6-99	21	70	22	67	19	69	20-6-99	19	79	21	75	18	83
4-6-99	21	75	23	68	18	83	21-6-99	20	79	21	75	19	69
5-6-99	19	79	21	67	18	83							
6-6-99	20	89	21	67	19	79							

Appendix III Temperature and Relative humidity recorded in the rearing room at MRS, Hebbal, Bangalore during third rearing

Date	Room temperature												
	Morning		Afternoon		Evening			Morning		Afternoon		Evening	
	Temp	RH	Temp	RH	Temp	RH	Date	Temp	RH	Temp	RH	Temp	RH
2-6-99	21	70	22	67	19	79	19-6-99	20	74	22	71	19	69
3-6-99	21	70	22	67	17	69	20-6-99	19	79	21	75	18	83
4-6-99	21	75	23	68	18	83	21-6-99	20	74	21	75	19	69
5-6-99	19	79	21	67	18	83	22-6-99	19	79	21	75	18	83
6-6-99	20	89	21	67	19	79	23-6-99	20	74	22	71	19	69
7-6-99	21	70	22	71	19	79	24-6-99	18	83	21	75	19	69
8-6-99	21	70	22	71	19	79	25-6-99	19	79	21	75	18	83
9-6-99	21	70	22	67	19	69	26-6-99	19	79	21	75	18	83
10-6-99	20	74	22	71	18	83	27-6-99	20	74	22	71	19	69
11-6-99	19	79	21	75	19	69	28-6-99	21	70	22	67	19	69
12-6-99	19	79	22	71	19	79	29-6-99	21	70	22	67	19	69
13-6-99	18	83	21	75	18	83	30-6-99	19	79	21	75	19	69
14-6-99	20	74	22	71	19	79	1-7-99	18	83	21	75	19	69
15-6-99	21	70	22	71	19	79	2-7-99	19	79	21	75	19	69
16-6-99	19	79	21	75	19	69							
17-6-99	18	83	21	75	19	69							
18-6-99	20	74	22	71	19	69							

Appendix – IV. Micro-climate changes recorded in the rearing trays during first rearing

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
1-1-99	T_1	19	83	21	75	19	83	5-1-99	T_1	18	74	20	65	19	79
	T_2	19	83	21	75	19	83		T_2	18	78	20	70	19	83
	T_3	19	83	21	75	19	83		T_3	18	78	20	70	19	83
	T_4	19	83	21	75	19	83		T_4	18	78	20	70	19	83
	T_5	19	79	21	71	19	79		T_5	18	74	20	65	19	29
2-1-99	T_1	20	68	21	75	19	83	6-1-99	T_1	20	65	21	69	19	79
	T_2	20	68	21	75	19	83		T_2	20	65	21	69	19	79
	T_3	20	68	21	75	19	83		T_3	20	68	21	74	19	83
	T_4	20	68	21	75	19	83		T_4	20	68	21	74	12	83
	T_5	20	65	21	71	19	79		T_5	20	65	21	69	19	79
3-1-99	T_1	20	79	22	71	18	74	7-1-99	T_1	19	79	22	71	18	74
	T_2	20	83	22	75	18	78		T_2	19	79	22	71	18	74
	T_3	20	83	22	75	18	78		T_3	19	83	22	75	18	78
	T_4	20	83	22	75	18	78		T_4	19	83	22	75	18	78
	T_5	20	79	22	71	18	74		T_5	19	79	22	71	19	74
4-1-99	T_1	18	74	20	65	19	19	8-1-99	T_1	18	74	21	69	19	79
	T_2	18	78	20	70	19	83		T_2	18	74	22	69	19	79
	T_3	18	78	20	70	19	83		T_3	18	78	21	74	19	83
	T_4	18	78	20	70	19	83		T_4	18	78	21	74	19	83
	T_5	18	74	20	65	19	79		T_5	18	74	21	69	19	79

Cont....

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
9-1-99	T_1	20	79	22	71	19	69	13-1-99	T_1	18.5	74	20	68	19	69
	T_2	20	79	22	71	19	69		T_2	18.5	74	20	68	19	69
	T_3	20	84	22	75	19	74		T_3	18.5	74	20	68	19	69
	T_4	20	84	22	75	19	74		T_4	18.5	78	20	70	19	74
	T_5	20	79	22	71	19	69		T_5	18.5	74	20	68	19	69
10-1-99	T_1	20	79	21.5	67	19	69	14-1-99	T_1	19	79	21	69	19	69
	T_2	20	79	21.5	67	19	69		T_2	19	79	21	69	19	69
	T_3	20	79	21.5	67	19	69		T_3	19	79	21	69	19	69
	T_4	20	84	21.5	70	19	74		T_4	19	83	21	74	19	74
	T_5	20	79	21.5	67	19	69		T_5	19	79	21	69	19	69
11-1-99	T_1	21	69	22	71	19	69	15-1-99	T_1	19	79	21.5	67	18.5	64
	T_2	21	69	22	75	19	69		T_2	19	79	21.5	67	18.5	64
	T_3	21	69	22	71	19	69		T_3	19	79	21.5	67	18.5	64
	T_4	21	74	22	75	19	74		T_4	19	83	21.5	70	18.5	69
	T_5	21	69	22	71	19	69		T_5	19	79	21.5	67	18.5	64
12-1-99	T_1	19	69	22	71	19	65	16-1-99	T_1	19	83	22	71	20	65
	T_2	19	69	22	71	20	65		T_2	19	83	22	71	20	65
	T_3	19	69	22	71	20	65		T_3	19	83	22	71	20	65
	T_4	19	74	22	75	20	70		T_4	19	89	22	75	20	70
	T_5	19	69	22	71	20	65		T_5	19	83	22	71	20	65

Cont……

Date		MICRO-CLIMATE													
		Temp	RH	Temp	RH	Temp	RH	Date		Temp	RH	Temp	RH	Temp	RH
17-1-99	T_1	20	79	21	62	18.5	64	21-1-99	T_1	21	62	22	71	19	69
	T_2	20	79	21	62	18.5	64		T_2	21	62	22	71	19	69
	T_3	20	79	21	62	18.5	64		T_3	21	62	22	71	19	69
	T_4	20	84	21	65	18.5	69		T_4	21	65	22	75	19	74
	T_5	20	79	21	62	18.5	64		T_5	21	62	22	71	19	69
18-1-99	T_1	20	79	21	62	19	69	22-1-99	T_1	20	79	22	71	18	74
	T_2	20	79	21	63	19	69		T_2	20	79	22	71	18	74
	T_3	20	79	21	63	19	69		T_3	20	79	22	71	18	74
	T_4	20	84	21	65	19	74		T_4	20	84	22	75	18	78
	T_5	20	79	21	62	19	69		T_5	20	79	22	71	18	74
19-1-99	T_1	21	62	21.5	59	19	69	23-1-99	T_1	20	79	21.5	67	18	74
	T_2	21	62	21.5	59	19	69		T_2	20	79	21.5	67	18	74
	T_3	21	62	21.5	59	19	69		T_3	20	79	2.15	67	18	74
	T_4	21	65	21.5	62	19	74		T_4	20	84	21.5	70	18	78
	T_5	21	62	21.5	59	19	69		T_5	20	79	21.5	67	18	74
20-1-99	T_1	20	79	21	62	20	65	24-1-99	T_1	21	62	22	71	19	69
	T_2	20	79	21	62	20	65		T_2	21	62	22	71	19	69
	T_3	20	79	21	62	20	65		T_3	21	62	22	71	19	69
	T_4	20	84	21	65	20	70		T_4	21	65	22	75	19	74
	T_5	20	79	21	62	20	65		T_5	21	62	22	71	19	67

Cont....

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
25-1-99	T_1	20	79	21	62	19	69	29-1-99	T_1	19	84	20	61	21	66
	T_2	20	79	21	62	19	69		T_2	19	84	20	61	21	66
	T_3	20	79	21	62	19	69		T_3	19	84	20	61	21	66
	T_4	20	84	21	65	19	74		T_4	19	89	20	66	21	70
	T_5	20	79	21	62	19	69		T_5	19	84	20	61	21	66
26-1-99	T_1	20	79	21	67	19	69	30-1-99	T_1	20	61	21	66	18	74
	T_2	20	79	21	67	19	69		T_2	20	61	21	66	18	74
	T_3	20	79	21	67	19	69		T_3	20	61	21	66	18	74
	T_4	20	84	21	70	19	74		T_4	20	66	21	70	18	78
	T_5	20	79	21	67	19	69		T_5	20	61	21	66	18	74
27-1-99	T_1	21	62	21.5	59	19	69	1-2-99	T_1	19	84	20	61	19	69
	T_2	21	62	21.5	59	19	69		T_2	19	84	20	61	19	69
	T_3	21	62	21.5	59	19	69		T_3	19	84	20	61	19	69
	T_4	21	65	21.5	62	19	74		T_4	19	89	20	66	19	74
	T_5	21	62	21.5	59	19	69		T_5	19	84	20	61	19	69
28-1-99	T_1	19	84	22	71	20	65								
	T_2	19	84	22	71	20	65								
	T_3	19	84	22	71	20	65								
	T_4	19	89	22	75	20	70								
	T_5	19	84	22	71	20	65								

Appendix V. Micro-climate changes recorded in the rearing trays during second rearing

Date		MICRO-CLIMATE													
		Temp	RH	Temp	RH	Temp	RH	Date		Temp	RH	Temp	RH	Temp	RH
21-5-99	T_1	20	84	22	75	18	78	25-5-99	T_1	18	74	20	79	18	74
	T_2	20	84	22	75	18	78		T_2	18	78	20	84	18	78
	T_3	20	84	22	75	18	78		T_3	18	78	20	84	18	78
	T_4	20	84	22	75	18	78		T_4	18	78	20	84	18	78
	T_5	20	79	22	71	18	74		T_5	18	74	20	79	18	74
22-5-99	T_1	20	84	21	65	18	78	26-5-99	T_1	19	69	20	79	17	78
	T_2	20	84	21	65	18	78		T_2	19	69	20	79	17	78
	T_3	20	84	21	65	18	78		T_3	19	74	20	84	17	84
	T_4	20	84	21	65	18	78		T_4	19	74	20	84	17	84
	T_5	20	79	21	62	18	74		T_5	19	69	20	79	17	78
23-5-99	T_1	19	69	21	62	19	69	27-5-99	T_1	19	69	20	79	18	74
	T_2	19	74	21	65	19	74		T_2	19	69	20	79	18	74
	T_3	19	74	21	65	19	74		T_3	19	74	20	84	18	78
	T_4	19	74	21	65	19	74		T_4	19	74	20	84	18	78
	T_5	19	69	21	62	19	69		T_5	19	69	20	79	18	74
24-5-99	T_1	19	69	21	67	19	69	28-5-99	T_1	20	79	21	62	19	69
	T_2	19	74	21	70	19	74		T_2	20	79	21	62	19	69
	T_3	19	74	21	70	19	74		T_3	20	84	21	65	19	74
	T_4	19	74	21	70	19	74		T_4	20	84	21	65	19	74
	T_5	19	74	21	67	19	69		T_5	20	79	21	65	19	69

Cont……

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
29-5-99	T_1	20	79	22	71	18	74	2-6-99	T_1	20	79	21	67	18	74
	T_2	20	79	22	71	18	74		T_2	20	79	21	67	18	74
	T_3	20	84	22	75	18	78		T_3	20	84	21	67	18	74
	T_4	20	84	22	75	18	78		T_4	20	79	21	70	18	78
	T_5	20	79	22	71	18	74		T_5	20	79	21	67	18	74
30-5-99	T_1	19	69	21	67	17	78	3-6-99	T_1	20	79	21	67	18	74
	T_2	19	69	21	67	17	78		T_2	20	79	21	67	18	74
	T_3	19	69	21	67	17	84		T_3	20	84	21	67	18	74
	T_4	19	74	21	70	17	84		T_4	20	79	21	70	18	78
	T_5	19	69	21	67	17	78		T_5	20	79	21	67	18	74
31-5-99	T_1	20	79	21	67	17	78	4-6-99	T_1	20	79	22	71	17	78
	T_2	20	79	21	67	17	78		T_2	20	79	22	71	17	78
	T_3	20	79	21	67	17	78		T_3	20	84	22	71	17	78
	T_4	20	84	21	70	17	84		T_4	20	79	22	75	17	84
	T_5	20	79	21	67	17	78		T_5	20	74	22	71	17	78
1-6-99	T_1	19	79	21	67	18	74	5-6-99	T_1	13	74	20	79	17	78
	T_2	19	79	21	67	18	74		T_2	13	74	20	79	17	78
	T_3	19	79	21	67	18	74		T_3	13	74	20	79	17	78
	T_4	19	84	21	70	18	78		T_4	13	78	20	84	17	80
	T_5	19	79	21	67	18	74		T_5	13	74	20	79	17	78

Cont........

Date		MICRO-CLIMATE													
		Temp	RH	Temp	RH	Temp	RH	Date		Temp	RH	Temp	RH	Temp	RH
6-6-99	T_1	20	79	21	67	18	74	10-8-99	T_1	18	74	20	79	18	74
	T_2	20	79	21	67	18	74		T_2	18	74	20	79	18	74
	T_3	20	79	21	67	18	74		T_3	18	74	20	79	18	74
	T_4	20	84	21	70	18	78		T_4	18	78	20	84	18	78
	T_5	20	79	21	67	18	74		T_5	18	74	20	79	18	74
7-6-99	T_1	20	79	21	67	18	74	11-6-99	T_1	18	74	21	67	18	74
	T_2	20	79	21	67	18	74		T_2	18	74	21	67	18	74
	T_3	20	79	21	67	18	74		T_3	18	74	21	67	18	74
	T_4	20	84	21	70	18	78		T_4	18	78	21	70	18	78
	T_5	20	79	21	69	18	74		T_5	18	74	21	67	18	74
8-6-99	T_1	20	79	21	67	18	74	12-6-99	T_1	17	78	20	79	17	73
	T_2	20	79	21	67	18	74		T_2	17	78	20	79	17	78
	T_3	20	79	21	67	18	74		T_3	17	78	20	79	17	78
	T_4	20	84	21	70	18	78		T_4	17	84	20	84	17	84
	T_5	20	79	21	69	18	74		T_5	17	78	20	79	17	78
9-6-99	T_1	19	69	21	67	17	78	13-6-99	T_1	19	69	21	67	18	74
	T_2	19	69	21	67	17	78		T_2	19	69	21	67	18	74
	T_3	19	69	21	67	17	78		T_3	19	69	21	67	18	74
	T_4	19	74	21	70	17	84		T_4	19	74	21	70	18	78
	T_5	19	69	21	69	17	78		T_5	19	69	21	61	18	74

Cont…….

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
14-6-99	T_1	20	79	21	67	18	74	18-6-99	T_1	19	69	21	67	18	74
	T_2	20	79	21	67	18	74		T_2	19	69	21	67	18	74
	T_3	20	79	21	67	18	74		T_3	19	69	21	67	18	74
	T_4	20	84	21	70	18	78		T_4	19	74	21	70	18	73
	T_5	20	79	21	67	18	74		T_5	19	69	21	67	18	74
15-6-99	T_1	18	74	20	79	18	74	19-6-99	T_1	18	74	20	79	17	78
	T_2	18	74	20	79	18	74		T_2	18	74	20	79	17	78
	T_3	18	74	20	79	18	74		T_3	18	74	20	79	17	78
	T_4	18	78	20	84	18	78		T_4	18	78	20	84	17	84
	T_5	18	74	20	79	18	74		T_5	18	74	20	79	17	78
16-6-99	T_1	17	78	20	79	18	74	20-6-99	T_1	19	69	20	79	18	74
	T_2	17	78	20	79	18	74		T_2	19	69	20	79	18	74
	T_3	17	78	20	79	18	74		T_3	19	69	20	79	18	74
	T_4	17	84	20	84	18	78		T_4	19	74	20	84	18	78
	T_5	17	78	20	79	18	74		T_5	19	69	20	79	18	74
17-6-99	T_1	19	69	21	67	18	74	21-6-99	T_1	18	74	20	79	17	78
	T_2	19	69	21	67	18	74		T_2	18	74	20	79	17	78
	T_3	19	69	21	67	18	74		T_3	18	74	20	79	17	72
	T_4	19	74	21	70	18	73		T_4	18	74	20	84	17	84
	T_5	19	69	21	67	18	74		T_5	18	74	20	79	17	72

Appendix – VI Micro-climate changes recorded in the rearing trays during third rearing

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
2-6-99	T_1	20	84	21	70	18	78	6-6-99	T_1	19	69	21	67	17	78
	T_2	20	84	21	70	18	78		T_2	19	74	21	70	17	84
	T_3	20	84	21	70	18	78		T_3	19	74	21	70	17	84
	T_4	20	84	21	70	18	78		T_4	19	74	21	70	17	84
	T_5	20	79	21	67	18	74		T_5	19	69	21	67	17	78
3-6-99	T_1	20	84	21	70	18	78	7-6-99	T_1	20	79	21	67	18	74
	T_2	20	84	21	70	18	78		T_2	20	79	21	67	18	74
	T_3	20	84	21	70	18	78		T_3	20	84	21	70	18	78
	T_4	20	84	21	70	18	78		T_4	20	84	21	70	18	78
	T_5	20	79	21	67	18	74		T_5	20	79	21	67	18	74
4-6-99	T_1	20	79	22	71	17	78	8-6-99	T_1	20	79	21	67	18	74
	T_2	20	84	22	75	17	84		T_2	20	79	21	67	18	74
	T_3	20	84	22	75	17	84		T_3	20	84	21	70	18	78
	T_4	20	84	22	75	17	84		T_4	20	84	21	70	18	78
	T_5	20	79	22	71	17	78		T_5	20	79	21	67	18	74
5-6-99	T_1	18	74	20	79	17	78	9-6-99	T_1	20	79	21	67	18	74
	T_2	18	78	20	84	17	78		T_2	20	79	21	67	18	74
	T_3	18	78	20	84	17	84		T_3	20	84	21	70	18	78
	T_4	18	78	20	84	17	84		T_4	20	84	21	70	18	78
	T_5	18	74	20	84	17	84		T_5	20	79	21	69	18	74

Cont.......

MICRO-CLIMATE

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
10-6-99	T_1	19	69	21	67	17	78	14-6-99	T_1	19	69	21	67	18	74
	T_2	19	69	21	67	17	78		T_2	19	69	21	67	18	74
	T_3	19	74	21	70	17	84		T_3	19	69	21	67	18	74
	T_4	19	74	21	70	17	84		T_4	19	74	21	70	18	78
	T_5	19	69	21	67	17	78		T_5	19	69	21	67	18	74
11-6-99	T_1	18	74	20	79	18	74	15-6-99	T_1	20	79	21	67	18	74
	T_2	18	74	20	79	18	74		T_2	20	79	21	67	18	74
	T_3	18	74	20	79	18	74		T_3	20	79	21	67	18	74
	T_4	18	74	20	84	18	78		T_4	20	84	21	70	18	78
	T_5	18	74	20	79	18	74		T_5	20	79	21	67	18	74
12-6-99	T_1	18	74	21	67	18	74	16-6-99	T_1	18	74	20	79	18	74
	T_2	18	74	21	67	18	74		T_2	18	74	20	79	18	74
	T_3	18	74	21	67	18	74		T_3	18	74	20	79	18	74
	T_4	18	78	21	70	18	78		T_4	18	78	20	84	18	78
	T_5	18	74	21	67	18	74		T_5	18	74	20	79	18	74
13-6-99	T_1	17	78	20	79	17	78	17-6-99	T_1	17	78	20	79	18	74
	T_2	17	73	20	79	17	78		T_2	17	78	20	79	18	74
	T_3	17	78	20	79	17	78		T_3	17	78	20	79	18	74
	T_4	17	34	20	84	17	84		T_4	17	84	20	84	18	78
	T_5	17	78	20	79	17	78		T_5	17	78	20	79	18	74

Cont…….

MICRO-CLIMATE

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
18-6-99	T_1	19	69	21	67	18	74	22-6-99	T_1	18	74	20	79	17	78
	T_2	19	69	21	67	18	74		T_2	18	74	20	79	17	78
	T_3	19	69	21	67	18	74		T_3	18	74	20	79	17	78
	T_4	19	74	21	70	18	78		T_4	18	78	20	84	17	84
	T_5	19	69	21	67	18	74		T_5	18	74	20	79	17	78
19-6-99	T_1	19	69	21	67	18	74	23-6-99	T_1	19	69	21	67	17	78
	T_2	19	69	21	67	18	74		T_2	19	69	21	67	17	78
	T_3	19	69	21	67	18	74		T_3	19	69	21	67	17	78
	T_4	19	74	21	70	18	78		T_4	19	74	21	70	17	84
	T_5	19	69	21	67	18	74		T_5	19	69	21	67	17	78
20-6-99	T_1	18	74	20	79	17	78	24-6-99	T_1	17	78	20	79	18	74
	T_2	18	74	20	79	17	78		T_2	17	78	20	79	18	74
	T_3	18	74	20	79	17	78		T_3	17	78	20	79	18	74
	T_4	18	78	20	84	17	84		T_4	17	84	20	84	18	73
	T_5	18	74	20	79	17	78		T_5	17	78	20	79	18	74
21-6-99	T_1	19	69	20	79	18	74	25-6-99	T_1	18	74	20	79	17	78
	T_2	19	69	20	79	18	74		T_2	18	74	20	79	17	78
	T_3	19	69	20	79	18	74		T_3	18	74	20	79	17	78
	T_4	19	74	20	84	18	78		T_4	18	78	20	84	17	84
	T_5	19	69	20	79	18	74		T_5	18	74	20	79	17	78

Cont……

MICRO-CLIMATE

Date		Morning		Afternoon		Evening		Date		Morning		Afternoon		Evening	
		Temp	RH	Temp	RH	Temp	RH			Temp	RH	Temp	RH	Temp	RH
26-6-99	T_1	18	74	20	79	17	78	30-6-99	T_1	18	74	20	79	18	74
	T_2	18	74	20	79	17	78		T_2	18	74	20	79	18	74
	T_3	18	74	20	79	17	78		T_3	18	74	20	79	18	74
	T_4	18	78	20	84	17	84		T_4	18	78	20	84	18	78
	T_5	18	74	20	79	17	78		T_5	18	74	20	79	18	74
27-6-99	T_1	19	69	21	69	18	74	1-7-99	T_1	17	78	20	79	18	74
	T_2	19	69	21	69	18	74		T_2	17	78	20	79	18	74
	T_3	19	69	21	69	18	74		T_3	17	78	20	79	18	74
	T_4	19	74	21	70	18	78		T_4	17	84	20	84	18	78
	T_5	19	69	21	69	18	74		T_5	17	78	20	79	18	74
28-6-99	T_1	20	79	21	69	18	74	2-7-99	T_1	19	69	20	79	18	74
	T_2	20	79	21	69	18	74		T_2	19	69	20	79	18	74
	T_3	20	79	21	69	18	74		T_3	19	69	20	79	18	74
	T_4	20	84	21	70	18	78		T_4	19	74	20	84	18	78
	T_5	20	79	21	69	18	74		T_5	19	69	20	79	18	74
29-6-99	T_1	20	79	21	67	18	74		T_1						
	T_2	20	79	21	67	18	74		T_2						
	T_3	20	79	21	67	18	74		T_3						
	T_4	20	84	21	70	18	78		T_4						
	T_5	20	79	21	67	18	74		T_5						