INTRODUCTION

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The art and science behind the silk production is known as sericulture. This involves host plant cultivation, silkworm rearing, spinning, reeling and finally weaving. The natural silks are broadly classified into mulberry and non-mulberry silk. Since non-mulberry sericulture is basically a forest based industry, it is known as wild silk. On the other hand, mulberry silkworm too, was first found centuries before either in the mountains of Himalayas or in China or in lower slopes of Eastern Himalayas, it was in wild state and causing damage to mulberry trees. For fine natural filament, it was brought under domestication for centuries and it became completely domesticated. However, the mulberry and non mulberry silkworm fauna having commercial values were presented in Table:INTRO : 1.

Silk and the silkworm

Silk fiber is nothing but a proteinaceous structure having core protein of fibroin with encircled gummy sericin produced from silk gland. The glands are second largest organs of the body, which occupy 2/5 of its body weight and volume and extended between 4th and 8th segment of the body. Larva spins from exterior to the interior in the shape of figure of eight (8). Depending upon the length and breadth of the worms it rotates around 60,000 to 3,00,000 times inside the cocoon in order to complete its nest. The formation of thread takes place at an average rate of 6 inches per minute.

Brief History of Sericulture :

The heritage of silk in India dates back to catholic age which was the integral component of Indian culture and life style. Since the medieval period, sericulture was patronised by the kings and Mugal emperors during 16th and 17th century (Chatterjee, 1993) Later, East India Company gave stimulus for the weaving Industry in United Kingdom (UK). Between 1761 and 1795 the export of Bengal raw silk to England was of the order of about 2.5 lakh kg. annually. In 1860, when pebrine disease smashed the silkworm crop in France and Italy, it was Kashmir that was able to supply 25000 oze of mulberry silkworm seed to Europe at a short notice. The industry showed down-falls from 1875 due to various reasons such as ravages of silkworm diseases and also the entry of Japan and China into the world market in a big way. Subsequently the export of raw silk ceased practically and large scale import of raw silk to India has started taking place to meet the needs of domestic silk weaving industry (Silkman Companion, 1992).

The accepted theory is that the origin of silkworm was in China about 2500 BC by domesticating wild silkworm, Bombyx mandarina. But we Indians strongly believe that silk production was in existence in India even when China discovered it in her own country. In India, scriptures like the "Rigveda", "Manusmriti", the "Ramayana", the "Mahabharat" references of silk, silk cloths and garments made of silk, are available.

Killing of live pupae inside the cocoon for obtaining good silk yarn was not liked by the then orthodox Hindu kings and queens. This is the reason why the real silk was not used in religious functions but "kete" and "mataka" cloths were used which are the product of pierced cocoons and silk waste. It is obvious that some kinds of silk were cultivated in India independently of China from the time immemorial. It, therefore, proves that different varieties of silk are obtained from different kinds of silkworms. The ancient records depict that sericulture industry has developed under the care of Chinese queen Shi-Ling-chi, wife of the Emperor, W'huang-ti who ruled over China about 2604 B.C. It is said, one day 14 year old queen was enjoying a tea ceremony in her palace garden with her friends and maids under a mulberry tree, suddenly a golden coloured cocoon dropped in her tea cup. When she tried to remove the cocoon from the tea cup, an end of the filament came out of the cocoon and it was a continuous one. Then she collected some more cocoons, carried them to her palace, preserved them till emergence and reared in the next generation and later invented better method of reeling and loom for weaving (Sarkar, 1977). The silk thus originated in China, has spread various regions of the world - Europe, Japan, Korea and Southern Asia through the so called "Silk Road" (Fig. 1) (Gamo, 1981; Hirobe, 1968; Nanavati, 1965). Later, on the basis of geographical distribution, they have been renamed as Japanese, Chinese, European and tropical races. Out of these four, first three are mostly either bivoltine or univoltine silkworm

varieties with a prevalence of diapausing character in the egg stage where-as the later being the tropical one is of polyvoltine nature with non-diapausing behaviour (except Barapolu which is univoltine in nature) enabling the silkworm rearers to take 6 to 8 crops per annum. These geographical varieties are being mainly used as physiological, genetical or as breeders' research materials.

World scenario :

Presently there are over fifty silk producing countries in the world ranging from a very small producers like France (400 kg of raw silk/annum) to the largest producer like China yielding 72000 tones which is 72.73% of total world raw silk production (TABLE : INTRO : 2). Our country stands next to China yielding 13.33% of total raw silk production of the world. The major producers in the order are - China, India, Japan, USSR, Brazil, N. Korea and South Korea. Silk production being a highly labour oriented and production cost becoming very high, the industrialised countries like France, Italy, Spain, and even Japan etc., are almost giving up the sericulture.

Status of India :

India, being a vast country, stretching from 70°E to 95°E longitude and from 35°N to 10°S latitude having high mountain ranges in the north and oceans in the South with an altitude

ranging from 0M.AMSL to more than 2500 M. AMSL (up to which regular population is available) is bestowed with a mulberry hectarage of 2,88,510 covering almost all states (TABLE - INTRO 3) (Annual Report, CSB, 1995) with an annual raw silk production of 14000 tonnes (Fig.INTRO 2) and an export of 558.86 sq.meters fabric which has earned a sum of Rs.86,250.69 lakh. This agro-based industry plays a vital role in the upliftment of rural economy encompassing more than 60 thousand sericultural villages wherein more than 61 lakh employment is generated (Annual Report, CSB, 1995).

Though almost the whole country has the soil and other agro climatic conditions suitable for mulberry cultivation and silkworm rearing yet the world bank aided N.S.P. (National Sericulture Project) has attended to as many as 12 new states in addition to the already existing three traditional sericultural zones : first is North, covering the states of J&K and its neighbouring states where exclusively uni/bivoltine crosses are reared; second is south, covering the states of Karnataka, Tamil nadu and Andhra Pradesh where multivoltine x bivoltine crosses are reared and the third one, covering the plains of West Bengal and adjoining states. In the last zone during the extremely hot and humid period multivoltine hybrids and during Autumn and Spring multi x bi and bi x bi crosses are reared (Sengupta 1991). Till 1985, West Bengal was ranking second in the raw silk

production but later the rate of production has been reduced as compared to Karnataka and Andhra Pradesh.

Sericulture in West Bengal & its constraints :

Sericulture, in West Bengal, is practiced mainly in Malda, Murshidabad and Birbhum (Fig.INTRO - 3) where the average land holding of a farmer is less than 0.5 acre with a varied typical tropical climate comprising of high temperature, high humidity to low temperature and minimum humidity (Fig. INTRO 4) due to which continuous rearing of silkworm is very difficult. On the other hand, the climatic conditions of Karnataka are more congenial throughout the year (TABLE.INTRO 4) and favourable for silkworm rearings that enables harvesting of 10 to 12 overlapping commercial crops in a year.

TABLE: INTRO 4. Average temperature & relative humidity of Karnataka (Anantha Raman et al., 1994)

Season	Temp.range	RH range
May - June (Summer)	28-31°c	60-70%
June - Sept.(Monsoon)	22-29°c	75-90%
Oct.- Feb. (Winter)	18-25°c	75-80%

Though sericulture, in West Bengal, is being practiced since time immemorial yet the indigenous mulberry variety (Morus sp.), ancient silkworm races like - Nistari, Debra and age old primitive traditional methods have become the major constraints

for the development of silk industry(Gupta et al,1996).The seasonal egg distribution and yield/100layings (Fig. 5) are revealing that out of the total distribution of 5.41 million DFls (Diseasefree layings) 55.19% were multivoltine,specially, Nistari, 43.58%were multi x bi, 1.077% being bivoltine Fls and 0.153% were bivoltine (Pl). Similarly, 19.27kg. / 100 DFLs produced from Nistari, 30.98kg. / 100 DFLs were produced from M x Bi, 19.7lkg. from Bivoltine (Pl) and 29.63kg. / 100 DFLs were produced from bi x bi hybrids (Annual report, NSSP, 1995-96). From the above statement , it was obvious that despite the considerable utilization and production of multi x bi hybrids still major inclination of the sericulture farmers is constantly persisting towards the utilization of Nistari layings. Nistari, though robust against harsh climatic condition yet is a low yielder in respect of yarn characters and therefore is unable to compete the international market (Datta 1984). In order to boost the production apart from minimising the constant use of Nistari layings and giving up of the age old traditional practices, it is essential to improve the silkworm breeds by introducing high yielding season specific Fl hybrids for commercial use.

Present Investigation :

The improvement in yield could be achieved through systematic breeding, the ultimate aim of which is the economic gain through scientific success which can be achieved through the selection, hybridization and population breeding approach (Sengupta, 1991).

The systematic breeding do not create any new gene but eliminate the deleterious genes and accumulate the beneficial ones which is only possible through selection and hybridization. Selective breeding is aimed at improving the existing ones and developing new breeds and hybrids which is essentially a creative process and is dependent on the study of genetic parameters and genetic architecture forming a basis for most appropriate selection scheme.

The selection of parental material on the basis of their genetic divergence, geographical distribution and per'se performances and some physio-morphological characters is one of the major key factors for the success of breeding scheme.

Sufficient information on the nature of gene action on important economic traits can be obtained through the application of diallel crossing (Jinks and Hayman 1953) provided certain assumptions are fulfilled.

At the same time a knowledge on the estimates of genetic components and their relative proportions controlling the expression of quantitative traits will help to understand the genetic architecture & gene action for a sound breeding programme.

The relative capacity of number of female and male parents to produce desirable hybrids by utilizing line x tester analysis

(Kempthrone, 1957) is well known (Arunachalam, 1974) for understanding certain gene action.

Further, the concept of choosing parents on the basis of their general combining ability for yield and its contributing traits would help in substantial genetic advance and assessing the nature and magnitude of gene action involved in various characters to formulate an essential breeding plan (Arunachalam and Bandyopadhyay, 1984; Sen et al., 1996),mainly to use the knowledge for exploiting heterosis in silkworms (Osawa and Harade, 1944; Harade, 1941, 1952, 1954, 1961; Yokoyama, 1957; Harade et al., 1961; Krishnaswami et al., 1964; Arunachalam, 1977; Gamo, 1981; Gamo et al.,1983; Arunachalam et al.,1984; Hirobe, 1985; Ashoka et al., 1990).

For the selection of high yielding genotypes the association between any two characters however may not give a correct picture of correlation. Therefore, the knowledge of direct and indirect effects through path analysis would help in understanding the complex situation of a particular trait.

Subject of the Investigation

On the basis of the available informations, scope of improvements on economic aspects and potentiality, the present investigator has concentrated on the following subjects :

i) To measure the nature and magnitude of gene action for quantitative traits in diallel population.

ii) To study the combining ability variance and effects in
(a) Diallel population and
(b) Line x tester population,

iii) To study the genetic components of variations,

iv) To study the magnitude of heterosis,

v) To provide the basis for an evaluation of selection scheme considering the parameters such as heritability Phenotypic Coefficient of Variation(PCV), Genotypic Coefficient Variation (GCV), genetic advance (GA), correlation coefficient and cause and effect relationship (Path analysis) and

vi) For the selection and recommendation of potential season specific hybrids for effective economic returns.

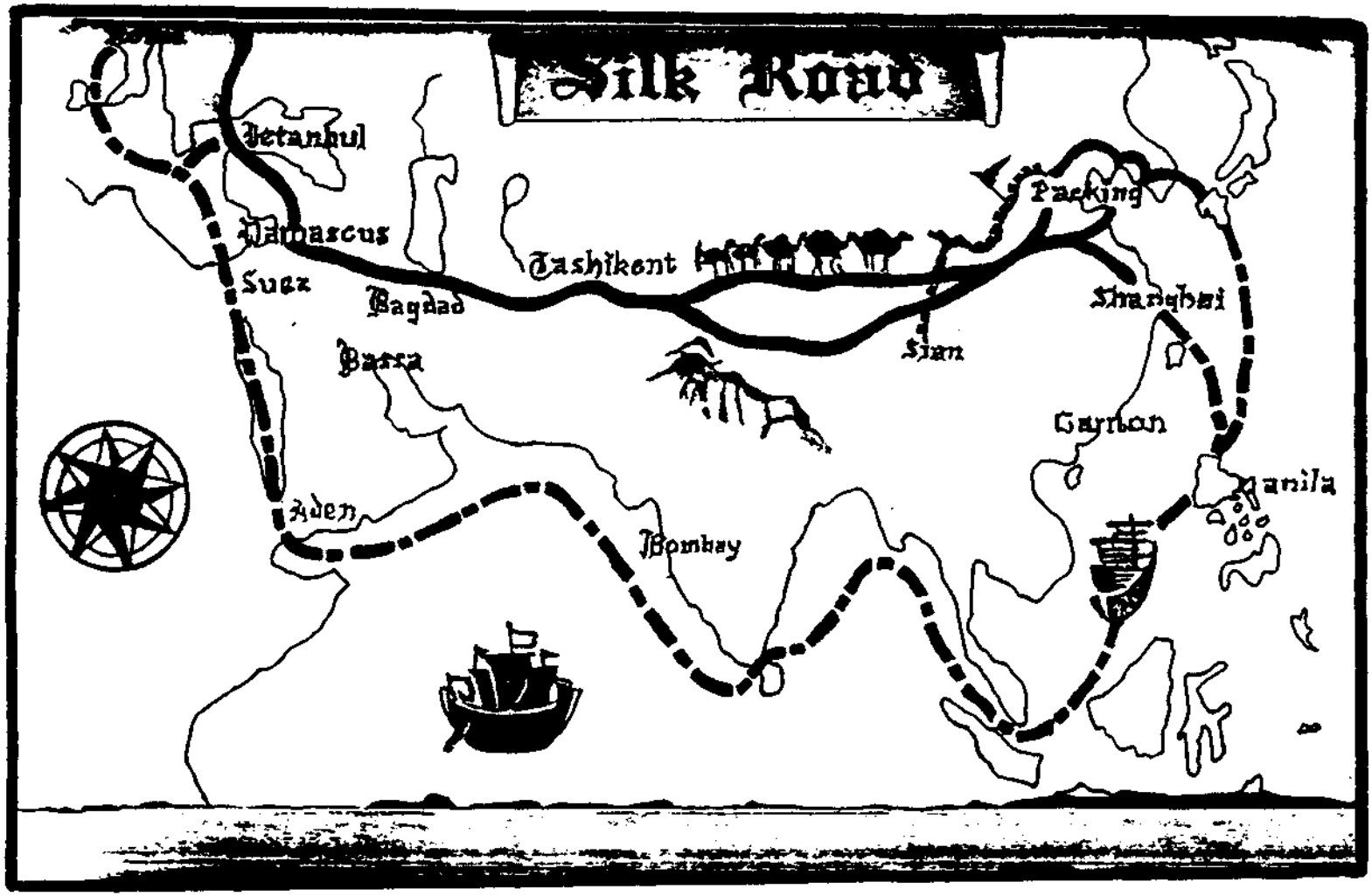
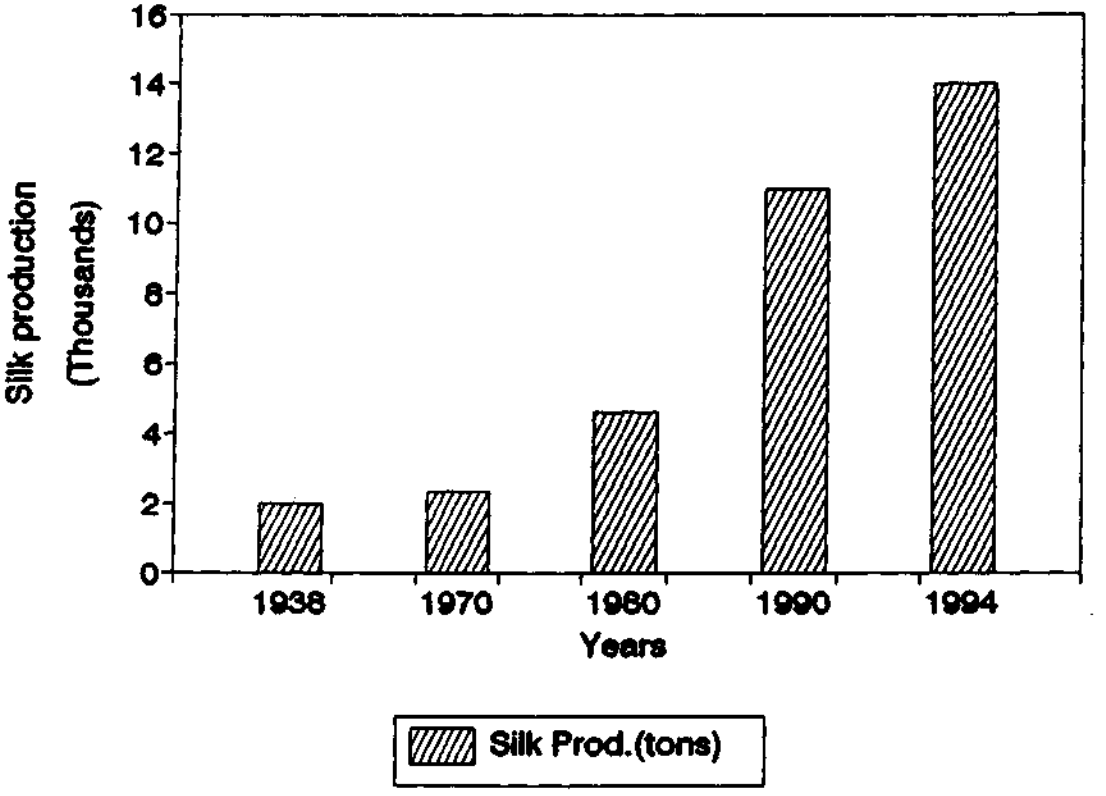


Fig.1showing the 6000 mile silk road passing through Tashkant, Bagdad, Damascus and Istanbul through which the fabulous silk from China and India were carried to Europe by 126 B.C.

RAW SILK PRODUCTION IN INDIA

FIG. 2




MULBERRY SERICULTURAL UNITS IN WEST BENGAL
PEDONG
KALIMPONG (RSRS., P_2 FARM., TSC., DCTC.)
DARJEELING
AMBARI FALAKATA (P_3 FARM)
JALPAIGURI
COOCH BIHAR
WESTDINAJPUR
DINHATA (TSC)
RAIGANG (SSPC)
KALIAGANJ (TSC)
DAKSHIN BHABANIPUR (SSPC)
AIHO (SSPC)
AMRITI (TSC)
MALDA
MALDA (RDO., RMB., DCTC., DCTC.)
BAGMARA (RSRS)
MOTHABARI (TSC)
SUJAPUR (TSC)
KALIACHAK (TSC)
KARNASUBARNA (P_2 FARM)
BHADRAPUR (TSC)
RAMPURHAT (SSPC, TSC.)
MURSHIDABAD
KANDI (SSPC, TSC)
BERHAMPORE (CSR&TI., SSPC)
PANCHGRAM (TSC)
KASHIPUR (NON-NSP. TSC)
KAMNAGAR (CFC)
BIRBHUM
SAKTIPUR (REC)
DHUBULIA (NURSERY-CUM
BANGURIA — P_1 FARM)
BURDWAN
NADIA
PURULIA
BANKURA
MOHANPUR (FIELD LAB)
SANTIPUR (REC)
HOOGLY
HOWRAH
BRA (TSC)
MIDNAPUR
INSKURA (SSPC)
24-PARGANAS
CALCUTTA

Fig. 3

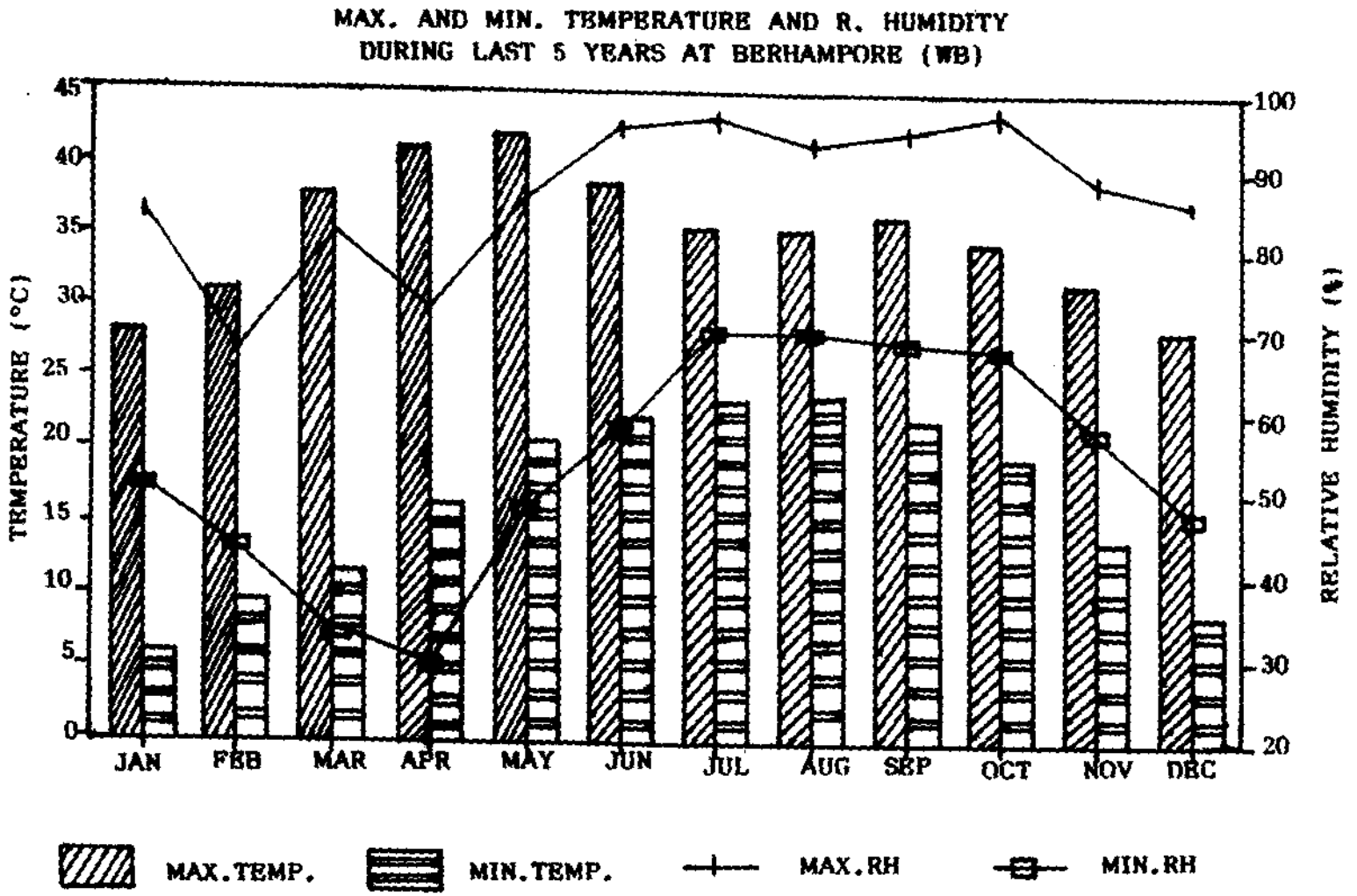

MAX. AND MIN. TEMPERATURE AND R. HUMIDITY
DURING LAST 5 YEARS AT BERHAMPORE (WB)
TEMPERATURE (°C)
RELATIVE HUMIDITY (%)
0
5
10
15
20
25
30
35
40
45
20
30
40
50
60
70
80
90
100
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
MAX.TEMP.
MIN.TEMP.
MAX.RH
MIN.RH

Figure - 4.

DFL Distribution & cocoon yield in W.B.

FIG. 5

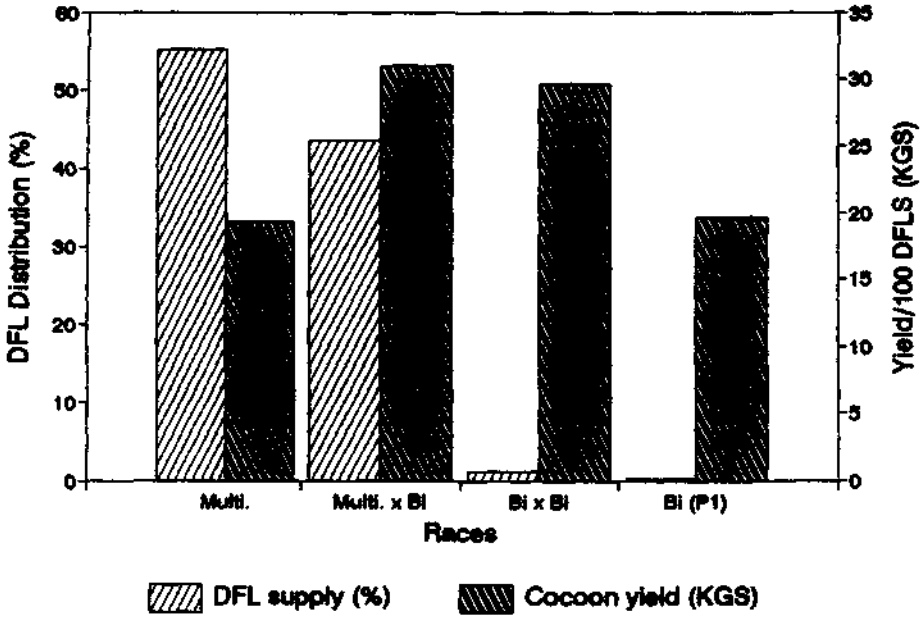


Table : INTRO : 1 : Non-mulberry and mulberry silk fauna having commercial value (Nanavati, 1965; Sengupta, 1991).

Silk varieties	Species	Distribution/location
Tasar silk	Antheraea mylitta D	Tropical India
	A. roylei	Temperate India
	A. pernyi GM	China
	A. frithi	India
	A. polyphemus	U.S.A.
Oak Tasar	A. proylei J	Temperate India
Muga	A. Assamma	Assam of India
Eri	Philosamia ricini	India
	P. cynthia	China, India New Guinea
Anaphe silk	Anaphe moleney Druce	Madagascar
Fagara	Attacus atlas	Southern & Central Africa
	Attacus edwardsi	India, Australia China, Sudan
Coan silk	Pachypasa otus D	Southern Nali Greece, Romania
Mulberry silk	Bombyx mandarina	Sub-Himalayan belt
	Teophila religiosa (presently no commercial value).	-do-
	Bombyx mori	China, India, Japan Korea, etc.
	Bombyx meridionalis (pure Mysore)	Karnataka
	Bombyx textor (Barapalu)	Birbhum & Murshidabad of WB
	Bombyx foraunatus (Chotopalu)	West Bengal
	Bombyx croesei (Nistari)	West Bengal

TABLE : INTRO : 2. ESTIMATED WORLD'S MULBERRY RAW SILK PRODUCTION (in tons)

COUNTRY	1990	1991	1992	1993	1994
CHINA	43800	48480	54480	69300	72000
INDIA	10200	10800	12600	13200	13200
JAPAN	4700	5520	5100	4200	3000
USSR	4020	4020	3600	3000	3000
BRASIL	1680	2100	2280	2340	2520
N. KOREA	1200	1300	1200	1200	1200
S. KOREA	780	660	660	840	780
OTHERS	2100	2000	2100	2100	2400
TOTAL	68480	74880	82020	96180	99000

TABLE : INTRO : 3. MULBERRY HECTARAGE DURING 1995-96

STATES	HECTARAGE
ANDHRA PRADESH	35546
ASSAM	2267
ARUNACHAL PRADESH	26
BIHAR	844
GUJARAT	210
HIMACHAL PRADESH	326
HARYANA	123
JAMMU & KASHMIR	3303
KARNATAKA	167422
KERALA	557
MADHYA PRADESH	4744
MAHARASTRA	1853
MANIPUR	25975
MIZORAM	1390
MEGHALAYA	843
NAGALAND	466
ORISSA	2442
PUNJAB	125
RAJASTHAN	1139
SIKKIM	12
TAMIL NADU	15188
TRIPURA	665
UTTER PRADESH	2270
WEST BENGAL	20774