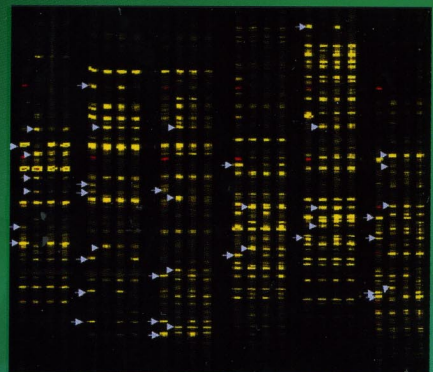


# Productive Silkworm Hybrids

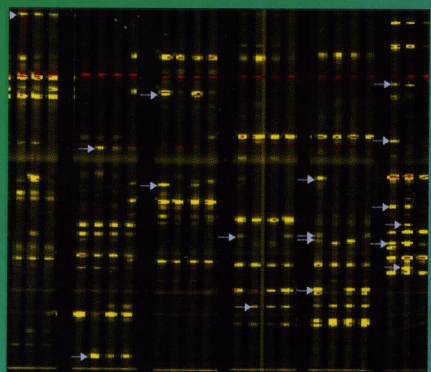
Swarnandhra, Kalpatharuvu & Hemavathy

APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.



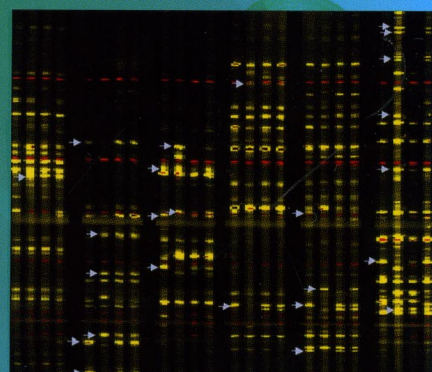
Swarnandhra

APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
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F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.

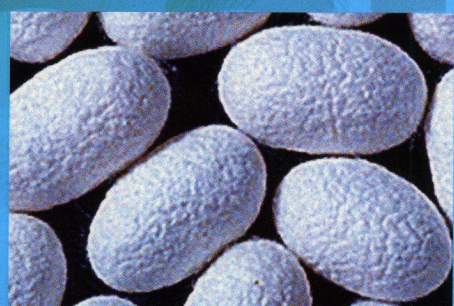


Kalpatharuvu

APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.  
APS<sub>2</sub>M  
APM<sub>1</sub>F  
F.F.



Hemavathy



**APSSRDI**

**Andhra Pradesh State Sericulture Research & Development Institute**

in collaboration with



**CDFD**

**Centre for DNA Fingerprinting & Diagnostics**



## **Sericulture in India**

India has emerged as an important and major sericulture country in the tropics. It has occupied a place of pride in global sericulture map being the homeland of all the four varieties of natural silks: Mulberry, Tasar, Eri and Muga. Mulberry silk alone accounts for about 90% of the total silk produced in the country. It is an important agro-based, labour-intensive and export oriented cottage industry. It holds promise as an employment generating industry especially in rural and semi-urban areas. In India, sericulture is practised in more than 60,000 villages involving over six million people and earning a valuable foreign exchange to the tune of 1755 crore rupees (1999-2000) annually by exporting various silk items. Since the Indian silk is ungraded as per the international standards, India is importing around 7000 tonnes of graded silk from China to meet the demand of power loom sector and silk exporting community. India ranks second among the mulberry silk producing countries of the world by producing 15,000 tonnes of silk which accounts for about 16% of total global silk production. The major silk producing Indian states are Karnataka, Andhra Pradesh, West Bengal, Tamil Nadu and Jammu & Kashmir.

## **Sericulture in Andhra Pradesh**

Andhra Pradesh (AP) is the second largest mulberry silk producer in the country. It also has a stretch of tropical tasar belt in Telangana region. In AP, Sericulture has been accepted as a sustainable rural economic activity and it embraces 1,14,000 small and marginal farmers inhabited in villages. It is widely practised in all the districts of the state with different agro-climatic zones. However, it is more concentrated in the Rayalaseema districts of Anantapur and Chittoor and sparsely distributed in Telangana and coastal districts of AP. Sericulture in AP has grown from mere 600 acres of mulberry cultivation in 1970-71 to 1,21,000 acres with a comparing increase in raw silk production from 50 tonnes to 4000 tonnes. Though there is continuous increase in the mulberry cultivation area and raw silk production, the low silk productivity, inferior quality of silk yarn and fluctuating cocoon yields are the impeding factors for the economically rewarding sericulture occupation. The productivity of silk per unit area is as low as 84 kgs per hectare of mulberry, which is far lower than 150 kgs of silk/ hectare produced in China.

## **Necessity for Productive silkworm Hybrids**

At present, 96% of the total silk production in AP is mainly contributed by the hybrid of Pure Mysore (PM) x bivoltine ( $NB_4D_2$ ) which is popularly called 'cross-breed' as in any other southern states. The silk produced from this hybrid is of inferior quality and silk productivity is considerably low. This has resulted in low financial returns to the silk rearers and silk reelers. The rearing of exclusive bivoltine hybrids which produce high quality silk is largely unsuccessful due to susceptibility of these hybrids to viral infections and high level of heat. All these problems have affected the economic sustainability of sericulture. Hence, adequate technology support to sericulture industry through intensive research and development activities directed towards development of productive high quality silkworm hybrids is a crucial factor to enhance the sericulture activity.

Keeping this in view, the government of AP established Sericulture Research and Development Institute (APSSRDI) in Hindupur of Anantapur district. APSSRDI is playing an anchor role by evolving highly productive and superior quality silkworm hybrids suitable to the tropical conditions and by providing technical know-how to the extension workers and farmers.

## **New Hybrids**

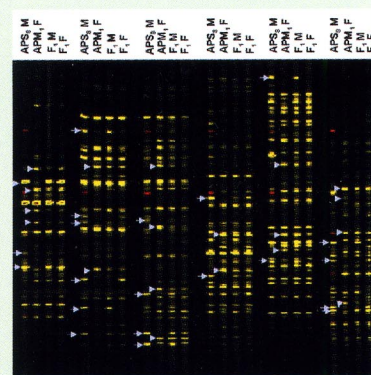
For the last five years, APSSRDI in collaboration with CDFD has focused its attention to evolve productive silkworm hybrids. So far, three high yielding hybrids, one polyvoltine ( $APM_1$ ) x bivoltine ( $APS_8$ ) hybrid named as "SWARNANDHRA" and two hardy bivoltine hybrids named as "KALPATHARUVU" and "HEMAVATHY" have been developed by adopting a combination of conventional selection and hybridisation and DNA technologies. These three hybrids give consistent silk cocoon yield and internationally graded raw silk.

## **Cross Breed: Swarnandhra**

The hybrid, 'Swarnandhra' is a cross-breed between female of  $APM_1$ , an elite polyvoltine inbred line developed using Madagascar hybrid as a donor parental genetic material and male of  $APS_8$ , which was developed from productive Chinese bivoltine hybrids. Both the inbred lines were isolated through selection for desired characters



and controlled progeny mating. Initially several recombinant inbred lines (RILs) were derived from an  $F_2$  population. The selection was exercised for desired characters such as larval survival, larval duration, silk cocoon and, cocoon shell weight, silk content, reelability and silk quality. These RILs were bred up to  $F_{10}$  generation. All these RILs were subjected to DNA fingerprinting technology using different DNA markers. Those RILs, which showed higher homozygosity (>90%) were chosen for further hybridisation studies. These inbred lines were also screened simultaneously for *Bombyx mori* densovirus1 (BmDENV1) resistance, which is a quite common viral disease of silkworm. The highly homozygous polyvoltine inbred RILs, which showed resistance to BmDENV1 were chosen to be crossed systematically with similarly developed bivoltine RILs to analyse their hybrid forming ability. Among many hybrid combinations tested for manifestation of hybrid vigour for survival rate and cocoon yield, the hybrid combination  $APM_1 \times APS_8$  turned out to be the best. It was further tested in different seasons of the year in different regions of AP and Karnataka to evaluate cocoon crop stability with the farmers. The traditional hybrid Pure Mysore  $\times NB_4D_2$  was always used as control. A quantity of 1,29,505 disease free egg layings (dfls) of Swarnandhra was reared and an average cocoon yield of 53.73 kg/100 dfls was obtained. The Swarnandhra cocoons fetched Rs.30 - 50 more per Kg of cocoons than the ruling hybrid Pure Mysore  $\times NB_4D_2$ . The yield profile of Swarnandhra is detailed in table 1.



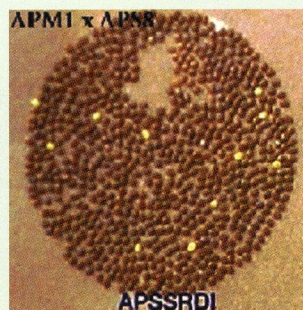
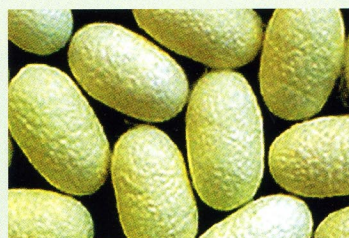
**Table 1. Seasonal Performance of Swarnandhra ( $APM_1 \times APS_8$ ) & Traditional Cross-breed ( $PM \times NB_4D_2$ )**

Season	No. Of Farmers Covered	No. Of Dfls Tested	Total Qty. Harvested (Kg)	Average Yield/ 100 Dfls (Kg)
<b>Swarnandhra</b>				
Summer	105	27480	15222.15	53.04 $\pm$ 6.95
Rainy	203	42050	23124.20	53.82 $\pm$ 7.73
Winter	235	59975	32004.95	54.48 $\pm$ 5.78
Total/Avg.	543	129505	70351.30	53.78 $\pm$ 6.82
<b>Cross-breed</b>				
Summer	160	24295	8338.04	34.32 $\pm$ 8.78
Rainy	185	35430	13640.55	38.50 $\pm$ 9.66
Winter	201	40345	16077.48	39.85 $\pm$ 10.65
Total/Avg.	546	100070	38056.08	37.56 $\pm$ 9.87

### Salient features of Swarnandhra

The eggs laid by the female parent of Swarnandhra  $APM_1$  are pigmented and non-diapausing. The pigmented nature of the eggs is controlled by the gene *pn<sup>d</sup>* (pigmented non diapause). The hybrid larvae are slender, elongated and bluish white in colour when fully grown and devoid of any visible markings on the larval body. The cocoons of  $APM_1$  are oval in shape and greenish yellow in colour whereas, the cocoons of  $APS_8$  are white in colour and peanut in shape. The hybrid cocoons are greenish yellow in colour imparted by the female parent  $APM_1$  with prominent oval shape and mild peanut appearance. The silk fibre reeled from Swarnandhra is greenish yellow in colour and of international grade (2A - 3A).

Swarnandhra is characterised by shorter larval period (22 - 23 days), heavier cocoon weight (1.60 - 1.70 g), and higher cocoon shell weight (0.290 - 0.320 g), higher survival rate (80 - 85%), improved silk reelability (80 - 90%), low renditta (7 - 7.5 Kg) and low floss percentage (less than 5%). The silk yarn is of international grade (2A - 3A). The comparative yield and quality advantages of Swarnandhra over the ruling traditional hybrid are given in table 2.





**Table 2. Yield profiles of Swarnandhra and traditional cross-breed**

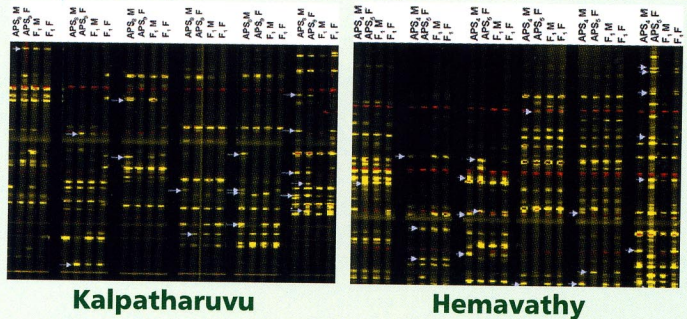
S. No	Yield Parameters	Traditional Cross-breed	Swarnandhra	Gain
1	Larval Period (days)	24-25	22-23	2-3
2	Survival (%)	60-70	80-85	15-20
3	Cocoon yield/100 dfls (Kg)	40-42	50-55	8-15
4	Cocoon shell ratio (%)	15-16	18-19	2-4
5	Filament length (m)	550-600	700-800	150-200
6	Reelability (%)	70-75	80-90	10-20
7	Renditta*	9.0-10.0	7.0-7.5	2-2.5
8	Grade of Silk	Ungraded	2A-3A	Intl. Grade

\* Quantity of cocoons (in kg) required to produce one kg of silk.

Swarnandhra performs consistently better than the ruling traditional hybrid in the varied climatic conditions of AP and Karnataka and holds promise of providing consistent cocoon yield and superior quality silk and thus assures higher financial returns to silkworm rearers and silk reelers.

### Bivoltine Hybrids: Kalpatharuvu and Hemavathy

The exotic Chinese and Japanese hybrids were used as donor parental genetic materials for the development of inbred lines APS<sub>9</sub>, APS<sub>8</sub>, APS<sub>5</sub> and APS<sub>4</sub>. The breeding was carried out for the desired characters particularly for cocoon shape (oval or peanut) and size, higher survival rate, shorter larval duration, heavier single cocoon and cocoon shell weight, longer silk filament, better reelability and superior quality of silk.



Initially, a number of recombinant inbred lines (RILs) were derived from two Japanese x Chinese hybrids. After F<sub>3</sub> generation, two sets of RILs were selected, one with oval cocoons and the other with peanut cocoons targeting the desired characters such as survival rate, heavier cocoon and cocoon shell, silk recovery. These RILs were also screened for resistance to *Bombyx mori* densovirus 1 (*BmDENV1*). DNA fingerprinting technology was used to estimate the zygosity status of the developed inbred lines. The highly inbred and homozygous lines (> 90%) were subjected to hybridization test. The excellent hybrid combinations APS<sub>9</sub> x APS<sub>8</sub> (Kalpatharuvu) and APS<sub>5</sub> x APS<sub>4</sub> (Hemavathy) were selected for further field trials.

Kalpatharuvu and Hemavathy, were field tested in different seasons and different regions of AP to evaluate the cocoon yield stability with the farmers. A quantum of 40425 disease free egg layings (dfls) which include 20340 dfls of Kalpatharuvu and 20085 dfls of Hemavathy yielded an average cocoon yield of 61.43 Kgs / 100 dfls. The cocoons fetched Rs.50 - 60 more per kg than the ruling polyvoltine x bivoltine hybrid, Pure Mysore x NB<sub>4</sub>D<sub>2</sub>. The silk fibre obtained from these hybrids is of 3A - 4A grade as per the international standard. The Yield profile of Kalpatharuvu and Hemavathy is given in table 3.

**Table 3. Seasonal performance of Hemavathy and Kalpatharuvu**

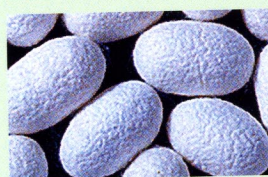
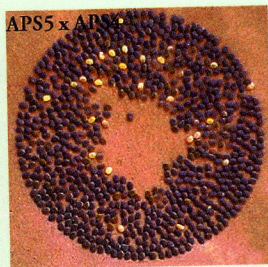
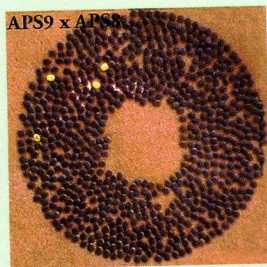
Season	No. Of Farmers Covered	No. Of Dfls Tested	Total Qty. Harvested (Kg)	Average Yield/ 100 Dfls (Kg)
Summer	26	5420	3238.52	60.83 ± 6.81
Rainy	39	7455	4467.90	60.21 ± 6.08
Winter	29	7210	4543.20	61.54 ± 6.78
<b>Total/Avg.</b>	<b>94</b>	<b>20085</b>	<b>12249.62</b>	<b>60.86 ± 6.56</b>
Summer	25	4940	2960.30	60.14 ± 7.19
Rainy	29	5395	3405.50	63.74 ± 6.95
Winter	43	10005	6305.90	62.04 ± 7.42
<b>Total/Avg.</b>	<b>97</b>	<b>20340</b>	<b>12671.70</b>	<b>61.97 ± 7.19</b>



## Salient features of Kalapatharuvu and Hemavathy

The eggs of both the hybrids are diapause in nature. Single mother moth lays 450 - 600 eggs. The silkworm larvae of the hybrids are devoid of any markings on the larval body. The fully grown larvae are stout, elongated and bluish white in colour. The cocoons of APS<sub>9</sub> and APS<sub>5</sub> are oval in shape whereas the cocoons of APS<sub>8</sub> and APS<sub>4</sub> are peanut in shape. The cocoons are compact with fine grains and smooth wrinkles. The hybrid cocoons are also oval in shape with mild peanut in appearance. Cocoon and yarn colours of all the parental inbred lines and hybrids are white.

Both the hybrids are characterised by shorter larval period (22 - 23 days), heavier silk cocoon weight (1.7 - 1.8 g), higher cocoon shell weight (0.350 - 0.390 g), higher shell ratio (21 - 22%), good larval survival rate (80 - 85%), better silk reelability (80 - 85%), lower renditta (6.5 - 7.0) and international grade silk (3A - 4A). The comparative yield and quality advantages of these bivoltine hybrids over traditional polyvoltine x bivoltine (Pure Mysore x NB<sub>4</sub>D<sub>2</sub>) hybrid are given in table 4.



**Kalpatharuvu**

**Hemavathy**

**Table 4. Superiority of New Bivoltine hybrids, Hemavathy and Kalpatharuvu**

S. No.	Parameter	Existing Hybrid	New B.V. Hybrids	Gain
1	Larval Period (days)	24-25	22-23	2-3
2	Survival (%)	60-70	80-85	20-25
3	Cocoon yield/100 dfls (Kg)	40-42	60-65	20-25
4	Cocoon shell ratio (%)	15-16	21-22	6-7
5	Filament length (m)	550-600	750-800	200-250
6	Reelability (%)	70-75	80-85	10-15
7	Renditta	9-10	6.5-7.0	2.5-3.0
8	Grade of Silk	Ungraded	3A-4A	International Grade

The large scale commercialisation of these hybrids not only ensures higher economic returns to the rearers and reelers over the currently reared hybrids, but also meet the industrial needs for export quality silk. Thus, the new hybrids not only enhance the sustainability of Indian sericulture but also curb the import of silk.

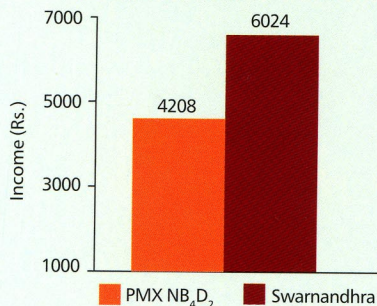
The new hybrids have increased the productivity levels with the farmers up to 20 % over the existing level of productivity from the traditional hybrids with an increased cocoon price of Rs.30 - 50 per Kg. As a result, the new hybrids fetch 40% increase in the earnings per acre of



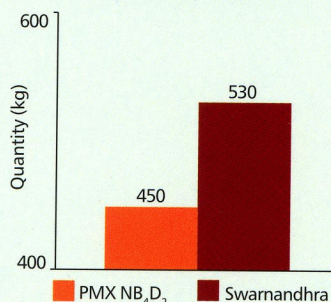
mulberry garden in one year. As a result of increased silk recovery and quality improvement reelers also gain around Rs. 2000 more than the traditional hybrid silk for every 100 Kgs of cocoons reeled. Since these hybrids also augmented the production of international grade (2A - 3A) silk, the import of silk from China could also be reduced to the extent of silk produced by these new hybrids. The new hybrids, by virtue of their merits in terms of consistent yield, superior quality silk and increased economic returns, have already gained the confidence of the farmers and have made inroads in to the other states such as Karnataka, Tamil Nadu, Maharashtra and Madhya Pradesh. By rearing the new hybrids in India there is a scope of producing a large quantity of international grade silk to meet the domestic demand for quality silk and also to earn the foreign exchange by exporting the international grade silk.

The new hybrids have been authorised for commercial use and have been filed for global patenting in Patent Corporation Treaty (PCT), Geneva.

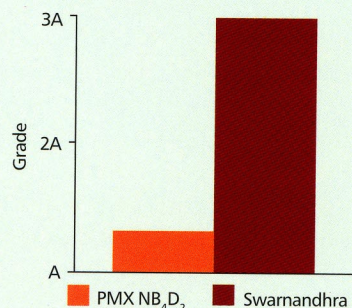
**Returns to Reelers  
(Rs. per 100 kg of Cocoons)**



**Cocoon Productivity  
(Kg/Area/Year)**



**Improvement in Silk Grade**



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