

TEN DAYS TRAINING PROGRAMME

ON

“INTEGRATIVE MODULE FOR MULBERRY BASED FARMING SYSTEM”

19th-28th DECEMBER, 2017

Patron

Prof. Nazeer Ahmad, Hon'ble Vice Chancellor, SKUAST-K

Convener

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*(Intercropping in mulberry, a sustainable income augmenting
venture for rural woman”)*

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Sher-e-Kashmir University of Agricultural Sciences & Technology of Kashmir

Prof. (Dr.) Nazeer Ahmed
Vice-Chancellor
FISVS, FHSI, FISHRD & FCHAI

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MESSAGE

It is indeed a matter of great pleasure that Temperate Sericulture Research Institute of our University is organizing a 10 days training programme on “Integrative module for mulberry based farming system” being organized under the DST funded project “Intercropping in mulberry - a sustainable income augmenting venture for rural women” w.e.f 19th to 28th December, 2017 and is also bringing out the training manual in this regard.

I am confident that the programme will provide an opportunity for the scientists, researchers and student scholars to learn and upgrade their knowledge, from eminent experienced resource scientists in the field. Such a training programme shall be of immense help in promoting the adoption of such an integrative mode of farming and improve the research and development activities in the field of sericulture.

I extend my best wishes to all the trainees and wish the event a grand success.


(Nazeer Ahmed)



Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir

Prof. M. Y. Zargar
Director Research

MESSAGE



I am very happy to learn that Temperate Sericulture Research Institute, Mirgund, SKUAST-K is hosting a ten days training on “Integrative module for mulberry based farming system” from 19th to 28th December, 2017. The focal theme i.e, “Mulberry based farming systems” of the training programme is very apt so far as the Himalayan state of Jammu and Kashmir is concerned. The state is known for its famous mulberry silk and it has a strong foothold in our state’s economy. Thus in order to address the issue of dwindling mulberry plantation due to their gradual replacement with orchards and vegetable gardens, an integrative module involving both mulberry and vegetables as intercrops can be a great way of saving the sericulture industry.

I am also happy to know that a training manual will be released during the valedictory function of the training programme. I congratulate and complement the organizers and their team for this endeavour.

I wish them good luck.

Prof. M.Y. Zargar



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Dr. K. A. SAHAF
Prof. & Head



MESSAGE

It is a matter of great pleasure that TSRI, Mirgund is organizing a 10 days training programme on “Integrative module for mulberry based farming system” from 19th to 28th December, 2017 under the DST funded project “Intercropping in mulberry- a sustainable income augmenting venture for rural women” wherein about 40 scientists/scholars from diverse fields are expected to participate.

The programme will provide a platform to the freshly recruited faculty, research scholars and students who will be bestowed with the latest technical know how in sericulture and allied fields so as to enable them to apply the same in their future research programmes which will become more applicable and beneficial for the farming community.

I extend my best wishes to all the trainees and wish the event and the organizers a grand success.

Prof. K. A. Sahaf

Sher-e-Kashmir
University of Agricultural Sciences and Technology of Kashmir
Temperate Sericulture Research Institute Mirgund



Dr Mushtaq Rasool Mir
Associate Professor, TSRI, Mirgund
(Course Director)

About the programme

Mulberry (*Morus Sp*) which is the only food to silkworm (*Bombyx mori* L.) can be trained as bush, dwarf and tree. The first two types of plantation are grown at narrower spacing as compared to the tree type of plantation which is more popular in Jammu & Kashmir state. Here the land is under tremendous pressure from other agricultural and horticultural crops and the farmers feel reluctant to devote their land for mulberry plantation. Further sericulture being a subsidiary occupation in the state does not appear to attract farmers. Integration of mulberry cultivation with other agricultural crops seems to provide an effective answer to these problems. This helps the farmer to get round the year employment and better returns through the sale of short duration vegetables and two crops of cocoons. This can go a long way to improve the mulberry wealth in the region the shortage of which has been identified as a major factor for the declining cocoon production in the region.

The programme aims to explain the integrative module for mulberry based farming system, through lectures from eminent and experienced scientists from different fields of agriculture. I hope the programme will provide a vibrant platform to the budding scientists, teachers and students to update their knowledge and skill to help them serve the students and farmers in a better way.

I wish the participants a comfortable and fruitful stay here.

A handwritten signature in black ink, consisting of a series of loops and strokes, followed by two small dots.

Editor/ Course Director



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CHAPTER 1: FUTURE STRATEGIES FOR SERICULTURE DEVELOPMENT IN KASHMIR

K. A. SAHAF

Temperate Sericulture Research Institute, Mirgund
Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir Srinagar (J&K)

Sericulture is generally promoted as industry for rural employment, poverty alleviation and foreign exchange earnings. Now focus has been shifted to quality improvement and increased production. In view of wide gap between domestic production and consumption of silk as indicated by imports of raw silk, Govt. of India has been fixing higher targets to bridge the gap in the past few five year plans and are making funds available to achieve the targets. There have been considerable improvements in productivity and quality in mulberry sector with raw silk production about 100 kg per hectare per year which has been achieved with improved high yielding mulberry varieties capable of producing as high as 70 MT of leaf per hectare per year. With the introduction of new high yielding silkworm hybrids cocoon production is about 60 kg in case of multi-voltine x bi-voltine crosses and 70 kg in bi-voltine hybrids per 100 dfls. Renditta of 8 and 6.5 has been achieved in multi-voltine x bi-voltine crosses and Bi-voltine hybrids respectively.

However, efforts have also been made to enhance bivoltine mulberry cocoon/silk production keeping in view its better quality viz., fineness, strength, shine and feel. The bivoltine sericulture development has been one of the priority sectors of Indian silk industry but its production is yet to meet the targets.

GLOBAL RAW SILK PRODUCTION

In North West regions of India sericulture is a subsidiary occupation due to limited rearing seasons and supplements the income of farmers. Temperate areas are bestowed with salubrious climate, ideally suited for bivoltine sericulture. Land availability, climate and socio-economic conditions of the region favour the development of bivoltine sericulture in the region. The existing mulberry trees scattered all over the region are the main source of bivoltine silkworm rearing in the region.

Jammu and Kashmir is the leading bivoltine cocoon producing among North West states of the India in terms of land under mulberry cultivation, cocoon production, raw silk production and number of rearers. Though Indian silk industry has progressed steadily but silk production and productivity in Kashmir is not encouraging. There is no dearth for technology, only appropriate implementation is needed.

TRAINING MANUAL ON “INTEGRATIVE MODULE FOR MULBERRY BASED FARMING SYSTEM”

Country	2010	2011	2012	2013	2014	2015	2016
Bangladesh	40	38	42.50	43	44.5	44	44
Brazil	770	558	614	550	560	600	650
Bulgaria	9.4	6	8.5	8.5	8	8	9
China	115000	104000	126000	130000	146000	170000	158400
Colombia	0.6	0.6	0.6	0.6	0.5	0.5	0
Egypt	0.3	0.7	0.7	0.7	0.82	0.83	1.2
India	21005	23060	23679	26480	28708	28523	30348
Indonesia	20	20	20	16	10	8	4
Iran	75	120	123	123	110	120	125
Japan	54	42	30	30	30	30	32
North Korea	-	300	300	300	320	350	365
South Korea	3	3	1.5	1.6	1.2	1	1
Philippines	1	1	0.89	1	1.1	1.2	182
Syria	0.6	0.5	0.5	0.7	0.5	0.3	0.25
Thailand	655	655	655	680	692	698	712
Tunisia	0.12	3	3.95	4	4	3	2
Turkey	18	22	22	25	32	30	32
Uzbekistan	940	940	940	980	1100	1200	1256
Vietnam	550	500	450	475	420	450	523
Madagascar	16	16	18	18	15	5	6
Total	139100.02	129661.80	152845.64	159737.10	178057.62	202072.83	192692.45

COCOON AND RAW SILK PRODUCTION DURING LAST FEW YEARS IN J&K

Year	Cocoon Production (MT)	Productivity per oz of seed (28 g) (Kg)	Avg. Price for “A” grade (Rs.)	Raw silk production (MT)	Rearers population (No.)
2008-09	738	32.00	192.00	82	19700
2009-10	810	35.00	300.00	90	22800
2010-11	860	35.00	410.00	107	25500
2011-12	917	37.00	350.00	116	27000
2012-13	901	37.00	397.00	112	28000
2013-14	1022	40.00	650.00	136	30000
2014-15	1032	37.00	625.00	147	30894
2015-16	944	37.00	582.00	135	30630
2016-17	973	40.00	667.00	145	30296

Poor infrastructure at all levels, un-organized mulberry plantation, low economic returns, inadequate forward and backward linkages like seed supply, poor extension support and poor cocoon marketing etc. are major concerns. Silkworm rearers are scattered, in different pockets, all over the states. Majority of the farmers in the region do not have separate rearing space, conduct silkworm rearing in their dwelling houses which does not provide true hygienic rearing conditions where even proper disinfection is impossible. These factors results in low productivity and thus poor income generation.

Sericulture in Kashmir is generally practiced on tree plantation scattered on road side, barren lands. Input management in the existing old mulberry trees is negligible with the result leaf is deficient in nutrients. Due to low survival of mulberry saplings in the field, the leaf production level does not show any significant improvement.

At present commercial rearing in whole of the North is generally restricted to spring season with only limited second crop. Most of the egg production centers of State Sericulture Department cannot maintain quality standard due to lack of proper infrastructure, equipments and expertise. Most of the farmers are supplied with incubated seed only and not the chawki worms. Chawki gardens to feed exclusively young age worms are generally not available with the farmers. Inadequate technological support available for diverse agro zones of the region. Lack of disease diagnosis facilities at farmers level.

Defective cocoon percentage is on a higher side in North India. This varies between 10-15% during spring season and 30-40% in autumn rearing. Reason for higher defective cocoon percentage is mostly the use of unsuitable mounting materials. Poor extension support and lack of adequate knowledge of the field staff about improved technologies. Reeling sector in north Indian sericulture is not as organized as in south India. Cocoon drying is mostly carried out by sun drying which affects the quality of the cocoon/silk. cocoon and raw silk the marketing system is very poor in the NW region which adversely affects the farming community associated with the sericulture as the rearers have either to sell their produce at very low price or have to wait months till marketing is organized by state Sericulture Departments. During this storage period enormous damage to the cocoons due to pest and predators takes place causing huge loss to farmers.

WHAT CAN BE THE FUTURE STRATEGY FOR SERICULTURE DEVELOPMENT IN KASHMIR

Create sustainable sericulture system that meets today's needs and those of future generations. An aggressive approach that can produce high yields and profits to farmers. Innovative government policies, both in science and economics of sericulture, research to further explore the interaction of all natural systems supporting farming and to produce appropriate new technologies, extension services to update farmers about new developments in sericulture technology as well as more constructive subsidy programmes than our current ones.

Majority of the farmers are practicing sericulture without proper rearing house or adequate rearing equipment, which affect the yield levels and quality of cocoons produced by them. The facilities of the farmers need to be strengthened either through financial assistance from the government programmes or banking institutions. Quality mulberry production of improved cultivars at farmer's level and also at the government/ community level. Quality silkworm seed of high yielding season / region specific hybrids has to be provided to the farmers for better productivity and also to ensure quality of the cocoons. Establishment of chawki rearing centers and only chawki reared worms should be supplied to rearers as is done in most of the sericulturally advanced states of the country. At present only 30% seed (in form of chawki worms) is being supplied to rearers. The silkworm rearers have to be educated about scientific methods of silkworm rearing, mulberry cultivation and disease prevention measures. This could be done by organizing demonstration cum training programmes. Integrated crop protection and pest management strategies for mulberry and silkworm are required for quality cocoon production.

At present commercial rearing in the Kashmir is mostly restricted to spring season only with 15-20% silkworm rearers conducting second commercial rearing and productivity is also low about 20-25 kg/100dfls as compared to spring season which is about 35-40 kg/100dfls. Extension of rearing to other seasons like late summer / early autumn is commercially feasible. This would go a long way in enhancing the economic viability of sericulture besides increasing the overall production. However, for taking up the double cropping pattern, the rearers need to be encouraged to establish mulberry plantations on their own land instead of depending on wild type mulberry growing on road sides etc. These stray plants are scattered and their input management is very difficult. For double cropping the rearers have either to spare separate sets of plantations for spring and late summer rearing.

Establishment of more reeling units in the region for timely utilization of the cocoons produced by the farmers. Very meager quantity *i.e.*, 25- 30% of the total cocoons production are reeled by local reelers while as rest of cocoons are purchased by outside reelers mostly from West Bengal. Department needs to strengthen the post cocoon reeling sectors of this industry.

MECHANIZATION

Promote mechanization in the mulberry cultivation and silkworm rearing to bring down the cost of cocoon production. As the availability of labour for agricultural operations are reducing due to migration of labour for non-agricultural operations, there is need to standardize the mulberry cultivation and silkworm rearing practices and introduce machines and tools to reduce the dependence of labour for sericulture operations.

PROMOTION OF SERICULTURE BASED INTEGRATED FARMING SYSTEM

Farmers have to utilize all available resources to maximise his profits. By integrating the compatible farm related activities such as crop enterprises, sericulture, diary, poultry, etc., the

farmer can effectively utilize the available resources to earn higher income at lesser cost. Developing economic farming models and practices towards optimum utilization of resources and reducing the cost of production aiming at self-sustainability. Intercropping pattern has to be disseminated to the farmers so that they can easily grow other crops in mulberry farms round the year both as Rabi Crops like turnip, peas, sag and garlic in winter and as Kharief Crops like beans, sag and soya bean to enable farmers to harvest more per unit area of land and increase the land use efficiency in a sustainable way.

SOCIAL FORESTRY

Social forestry schemes have made a considerable difference in overall forest cover in short time. Under social forestry programmes, afforestation is conducted outside the conventional forest area for the benefit of rural and urban communities with special emphasis on fuel and fodder development on all degraded lands/forests. Mulberry being a hardy and perennial plant can be cultivated in all kinds of land and agro-climatic conditions even with or without irrigation facilities.

SERICULTURE DEVELOPMENT IN NEW AREAS

The area under mulberry cultivation is declining in the recent years due to urbanization in the traditional sericulture belts. Efforts need to be made to introduce sericulture activities in non-traditional and economically backward areas where other avenues of livelihood are less. Adoption of cluster approach for sericulture development. Cluster approach is the best way to create infrastructure and impart the skills to farmers on silkworm rearing. Each cluster can be provided with the basic facilities such as sufficient staff for providing technical guidance and training the farmers, input supply mechanism, marketing facilities for cocoon etc to sustain the sericulture activities successfully even after withdrawal of government programmes.

VALUE ADDITION

Value addition and waste minimization are some ways which can increase the profitability in sericulture. To make sericulture more profitable, utilization of other products like mulberry fruit for the preparation of mulberry syrup and jam, utilization of seri-waste for vermin-composting/mushroom production and cocoon craft preparation is to be popularized at the farmers level.

PRODUCT DIVERSIFICATION

Traditionally silk is used for making fabrics. But now many products which have uses such as pharmaceutical, cosmetics, health, etc., have been developed from the mulberry, silkworm, silkworm pupae and their by-products. The commercial use of such products should be explored to improve the profitability from sericulture activities.

SERICULTURE EXTENSION: DEMANDS AND INADEQUACIES

All people desire higher goals in life. Once people are convinced of the value of new methods and that the new methods will help them reach their goal, they will change to attain the desired goal. The major task of extension is to convince the people of the value of new and better practices. Extension is essentially a dissemination of information (diffusion) and skill building (education). We take technology to the farmers but do little to educate them about their methodology. The gap between technology generation and adoption at field level is quite wide. Developing a farmer led extension approach namely lead farmer field school (FFS). Sericulture promotion through public-private partnership. Replication of success stories among the farmers. Regular training programmes for farmers in general and women in particular. Focus on women friendly technologies is required. Besides creation of women development cell in field offices, providing incentives to women for setting up units in pre and post cocoon sectors will encourage women rearers/ reelers. There is lack of women self help groups in sericulture activities. Initiatives are to be taken to create women only self help groups which can play major role in encouraging women participation in silk industry. Changing the present system of general subsidy to production-linked incentives. Arrange frequent re-fresher training for departmental extension staff.

MARKETING SYSTEM

Well organized marketing system is essential for stimulating production and consumption of any commodity. The cocoon/silk marketing system is very good in Karnataka but it is not developed in J&K. Strengthening the market system for safeguarding the interest of farmers is needed for the development of sericulture in NW regions especially the temperate zones. Effective marketing system for speedy disposal of produce at better rates is required to encourage the farmers towards sericulture. Cocoon grading facility needs to be created so that farmers get proper price of their produce. Establishment of cocoon bank facility with enough revolving fund will enable reelers to run their units throughout the year. There is requirement for the backward and forward linkages.

THRUST AREAS OF RESEARCH

- Collection and characterizing all the available mulberry and silkworm genetic material for key characters needed by the breeders, develop a database and identify the core germplasm.
- Development/identification of various region specific mulberry genotypes suitable for different agro-climatic zones of valley.
- Evolution and identification of mulberry genotypes tolerant to abiotic stress.

- Improving the soil health and soil fertility through cultivation practices with reduced use of chemical fertilisers and pesticides and increased usage of organic and biological inputs and *in situ* nutrient management
- Income generation in mulberry through intercropping.
- Evolution /identification of season specific silkworm breeds/hybrids suitable for different agro climatic conditions of North west region.
- Develop silkworm breeds tolerant against biotic and abiotic stress.
- Identification of high productive double hybrids for commercial exploitation.
- Incorporating multiple disease resistance through pyramiding of genes.
- Developing a long term pest and disease monitoring system and developing prediction models.
- Value addition in sericulture through effective utilization of byproducts and left over material.
- Popularization of organic farming through utilization of biofertilizers and other organic manures.
- Aforestation through mulberry plantation.
- Cost input reduction and effective space utilization through popularization of low cost rearing technologies.
- Biotechnological and molecular biological tools to expedite development of trait specific silkworms and their host plants
- Development and adoption of mechanization in silk production process to reduce dependency on hired labour and drudgery to attract younger generation.
- Focus on harnessing non-conventional energy, integrated farming system to reduce input cost and increase the income of stakeholders

CHAPTER 2: INTEGRATIVE APPROACH IN MULBERRY CULTIVATION- AN ANSWER TO LEAF SHORTAGE AT FARMERS’ LEVEL IN KASHMIR

Mushtaq Rasool Mir, Irfan Latif Khan, M.F. Baqual and Muneesa Bandy

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Sericulture is a traditional agro-industry in Jammu & Kashmir state but the production of silk declined during the last decade because of stiff competition with other horticultural and agricultural crops. Though an easy, less time consuming but a good revenue generating activity, the number of farmers showed a marked decrease because of many reasons and one important reason among them being the non availability of quality mulberry leaf with the farmers. Mulberry (*Morus spp*) is the only food to silkworm (*Bombyx mori* L), which is reared to produce the silk, the queen of textiles. Among many other factors, the leaf of mulberry has been found to contribute the greatest towards the success of silkworm rearing. It contributes 38.2 percent towards the success. Under Kashmir conditions, mulberry is grown in a scattered manner on farm boundaries, river bunds, and road sides and the plant does not get much attention as far as the nutrient application and other cultural activities are concerned. Among many other reasons, the subsidiary nature of sericulture is one. The farmers spent much of their time in collecting and transporting the leaf from far off places which reaches the worms in a withered and inferior quality thereby resulting in reduction of cocoons both quantitatively and qualitatively. This makes silkworm rearing less remunerative and the rearers switch to activities which guarantee more of returns, employment and cash flow. Mulberry as a monoculture does not seem to attract the farmers who feel reluctant to devote their land exclusively to mulberry cultivation as only one crop is taken at farmers level that too for a period of less than a month during May-June. Though second crop too is possible under Kashmir conditions, being less economic has not picked up at farmers level. Thus horizontal expansion rather than vertical expansion hold promise provided sericulture is practised in an integrative manner with other farming activities to enable the farmer to get multiple products for diverse use. Sericulture is suitable to be taken up with livestock rearing by feeding the left over leaf to livestock animals, poultry and fish farming by feeding them with pupal meal and using the rearing waste and litter for mushroom growth and compost for other agricultural and horticultural crops. In addition to these the plant finds use

in many other ways like jam and juice production, furniture and charcoal production. But growing mulberry and other crops in association could help to get diverse products to fulfill the different needs of the farmers besides meeting the following advantages :-

- ✓ Reducing the insect/mite pest populations because of the diversity of the crops grown. When other crops are present in the field, the insect/mite pests are confused and they need more time to look for their favorite plants.
- ✓ Reducing the plant diseases. The distance between plants of the same species is increased because other crops (belonging to a different family group) are planted in between.
- ✓ Reducing hillside erosion and protects topsoil, especially the contour strip cropping.
- ✓ Attracting more beneficial insects, especially when flowering crops are included the cropping system.
- ✓ Minimizing labor cost on the control of weeds. A mixture of various crops gives often a better coverage of the soil leaving less space for the development of weeds.
- ✓ Utilizing the farm area more efficiently.
- ✓ Resulting in potential increase for total production and farm profitability than when the same crops are grown separately.
- ✓ Providing two or more different food crops for the farm family in one cropping season.
- ✓ Providing Insurance against total crop failure under aberrant conditions or pest/disease epidemics.

Mulberry as a companion plant has an edge over other tree species that it has a very good regeneration capacity and under tropical conditions where there is no winter, leaf can be harvested in more than 5 flushes but under temperate climatic conditions of Kashmir, due to the winter dormancy, mulberry bears foliage from April to November only but even then, unlike other tree species of the region, two flushes of leaf can be harvested in a year from the same plant in the short span of just 05 months. It is a hardy plant which can be grown under varied agroclimatic conditions ranging from tropical to temperate climatic conditions. It has remarkable features which enable this plant to thrive equally well under these conditions and also under both rainfed and irrigated conditions. Given timely pruning, the plant remains mostly free from pests and diseases. It can be grown under various social forestry programmes on forest land, waste land and other public lands. The most important is that this plant remains without

leaf during a good period of a year (almost more than 06 months) as explained below giving ample chances for other crops to grow beneath.

Mulberry in Kashmir remains dormant during the winter. The winter buds start sprouting from 4th week of March onwards. The leaves increase in size gradually and are fed to silkworm during May- June, i.e. spring crop, which is the main crop in this region. This is followed by pruning of the shoots right from the crown base during 2nd week of June. The buds sprout again and shoots attain a very good height up to the end of September besides bearing luxuriant leaf. The leaf is either plucked again to feed the livestock animals and silkworm (2nd Crop) or is left as such to undergo senescence and natural fall during November. The plants remain dormant and bereft of any leaf up to March next as shown in Table-1.

Table 1: Period during which mulberry is devoid of leaf under Kashmir Conditions

S.No	Duration	Time(months)	Reasons for non availability of leaf
1.	January to 15 th April	3.5	Winter Dormancy
2.	June 2 nd week to July last	1.5	Harvesting of leaf along with shoots for spring rearing (Main crop)
3.	November-December	02	Leaf fall
Total		7.0	

From the above it is clear that the mulberry plant remains without leaf or have small shoots/canopy during a major part of the year. This coupled with the capacity of the plant to grow as trees with a canopy height sufficient to allow sunlight to reach the ground makes this plant very suitable for its integration with other agricultural crops thereby proving its feasibility to be used in as a companion crop with other crops. Mulberry seems to be the most fit plant under which we can grow other crops as well because the annual growth cycle is such that during major portion of the year, sufficient light remains available for other crops to be grown beneath mulberry plantation. Introduction of mulberry based agricultural modules could go a long way in making sericulture a sustainable occupation. It will help the farmers to get work as well as the cash flow throughout the year besides meeting their daily requirement of vegetables which are becoming very expensive. This can go a long way towards environment amelioration and climate change mitigation.

The crop combinations (Table-2) have been tested which have yielded encouraging results supporting the idea to use this plant as a companion crop with short duration vegetables to enable the farmer to get two crops of mulberry leaf for his worms and also vegetable crops, thereby helping him to put his land labour and other resources to an efficient use.

Table 2: Crop combinations

Treatment	Tree used	Agricultural crop	
		Rabi season	Kharif season
T-1	Mulberry at 9X9 spacing	Onion	Rajmash
T-2	-----Do-----	Garlic	Rajmash
T-3	-----Do-----	Turnip	Rajmash
T-4	-----Do-----	Peas	Sag
T-5	-----Do-----	Sag	Rajmash
T-6	-----Do-----	Nil	Nil

The module involves:-

- Planting mulberry trees having a canopy height of six feet at a spacing of 9x8' spacing.
- The plantation is maintained as per the package of practices for mulberry cultivation
- After establishment the leaf is harvested for the spring crop of silkworm rearing initially by individual plucking followed by shoot harvesting during the second week of June coinciding with the annual pruning to the plants.
- Short duration vegetables can be grown beneath the plantation as per the details furnished in Table 3:-

Table 3: Schedule for sowing and harvesting of short duration vegetable crops

Rabi crop			Kharif Crop		
Crop	Sowing	Harvesting	Crop	Sowing	Harvesting
Onion	Last week Oct.-15 th of November	Last week of May-15 th June	Rajmash	1 st June-20 th June	August/September
Garlic	Last week Oct.-15 th of November	Last week of May-15 th June	Rajmash	1 st June-20 th June	August/September

Turnip	Last week of August	Last week of November-February last	Rajmash	15 th April-20 th June	15th July-Ending August
Peas	Last week Oct.-15 th of November	Last week of May-15 th June	Sag	1 st June-20 th June	August/September
Sag	Last week of August-15 th September	Last week of November-February last	Rajmash	15 th April-20 th June	15th July-Ending August

After recordal of observations on growth and yield of mulberry during both the crops- Spring and autumn, it was clear that there was not any adverse effect on the growth and production of mulberry tree by growing vegetables both during the rabi and the Kharif seasons. This seems that there has not been any competition between the companion crops as far as the nutrient utilisation is concerned.

Table 4: Growth and yield in mulberry under different crop combinations during Spring

Treatment	No.of shoot-lets per plant	Total shoot length/plant	Leaf yield /plant
T-1 (Onion+Rajmash)	59.21	35.56	4.30
T-2 (Garlic+Rajmash)	59.21	34.41	3.81
T-3 (Turnip+Rajmash)	59.98	35.51	3.97
T-4 (Peas+Sag)	60.42	34.66	3.79
T-5 ((Sag+Rajmash)	60.24	35.02	3.76
T-6 (Control)	60.21	34.81	3.79
F.test	NS	NS	NS

Table 5: Growth and yield in mulberry under different crop combinations during Autumn

Treatment	No.of branches per plant	Total shootlength/plant	Leaf yield /plant
T-1 (Onion+Rajmash)	18.79	26.07	3.92
T-2 (Garlic+Rajmash)	19.25	28.15	4.19
T-3 (Turnip+Rajmash)	18.50	26.82	3.79
T-4 (Peas+Sag)	18.33	26.14	3.60

T-5 ((Sag+Rajmash)	18.29	26.30	4.28
T-6 (Control)	19.01	25.71	3.65
F.test	NS	NS	NS

The details of crop harvested and revenue generated through the sale of vegetables are furnished in Table-6.

Table 6: Income through mulberry based agroforestry system

Treatment	Rabi yield (Kg)	Kharif yield (Kg)	Income by sale of		Total Income (Rs)	Production cost (Rs)	Net income (Rs)
			Rabi crop (Rs)	Kharif crop (Rs)			
T-1 (Onion+Rajmash)	20	09	200	90	290	100	190 (58727)
T-2 (Garlic+Rajmash)	18	09	270	90	360	200	160 (49455)
T-3 (Turnip+Rajmash)	25	09	250	90	340	100	240 (74182)
T-4 (Peas+Sag)	15	20	150	200	350	120	230 (71090)
T-5 ((Sag+Rajmash)	20	09	200	90	290	100	190 (58727)
T-6 (Control)	Nil	Nil	Nil	Nil	Nil	Nil	

(Figures in parenthesis represent estimated values for 1 hectare of land)

The perusal of Table 6 indicates that a farmer can earn more than 50,000/ ha/ annum by following the module. However the foliage production increases after the trees are fully established and they remain productive even after 50 years. The leaf can be fed to silkworms and two crops of cocoons harvested per year which will help to improve the returns and the economic conditions of the farmers.

In one hectare of land approximately 1500 plants are possible at a spacing of 9 x 8 feet spacing. A total of 18600 Kg leaf can be harvested during Spring@12Kg per tree and 22500Kg during late summer/early autumn @15Kg per tree as the leaf production is more during the 2nd crop as compared to the 1st crop.

CHAPTER 3: PROPAGATION OF MULBERRY THROUGH POLYHOUSE TECHNOLOGY

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Agriculture continues to constitute the backbone of Indian economy and its various components play indispensable role in elevating the rural economy of Indian subcontinent in general and that of J and K state in particular. Over 70 per cent of the population, of more than 1.25 crores depends, directly or indirectly, on agriculture. Sericulture which is a science of silk production is one of the vital components of agriculture and consists primarily of two different sectors including mulberry cultivation and silkworm rearing. Mulberry cultivation being on farm activity where as silkworm rearing is on farm associated with raising of silkworms for eventual cocoon production.

Silkworm being monophagous insect is highly host specific and feeds on mulberry leaf only. The quality and quantity of cocoon production is determined by nutrient status of leaf. The acreage under mulberry continues to remain stagnant at approximately 3500 hectares. In order to give boost to sericulture industry through increased involvement of silkworm rearers with it, it is very essential to mass multiply mulberry plants and sell them to genuine planters and minimize the gap between uprooting of plants from nursery and their replanting in field. The longer the period, the higher is the mortality due to dryage and desiccation of roots. Maintenance of plantation through effective methods of irrigation and proper protection of newly and juvenile plants to minimize animal attack needs to be ensured on priority. Year after year although plantation is made, yet the mortality suffered by plants and as such the dearth of mulberry leaf in the field continues to pose serious threat for the sustenance of industry. As such some of the major steps need to be taken up for upliftment of the industry and for its value addition which would in turn make it more farmer friendly through their income augmentation. In this direction the main focus has to be towards raising of mulberry on a larger scale involving easy to practice and economically viable methods. One such method is raising of mulberry under polyhouse which is popularly called polyhouse technology generated by Temperate Sericulture Research Institute, one of the constituent units of SKUAST-K. Through this technology mulberry plants of suitable height for supply to field can be raised in two years time only as against 5 years being

taken through grafting technique. Further, the raising of plants through polyhouse technology is not only cheap but does not also involve any high level of skill. The salient features/methodology of raising saplings under polyhouse technology are as under:

- Disease free cuttings of 15 -20 cm length and 1.2 -1.5 cm diameter with 3-4 active buds are to be selected from 8-10 months old shoots.
- The cuttings should be treated with 0.02% Bavistin solution at the cut ends for half an hour to ensure protection against fungal diseases.
- Well punctured polythene bags (4.5 inches diameter and 11 inches height) should be filled with rooting medium comprising sand, soil and well decomposed FYM in the ratio of 6:3:1. The treated cuttings should be gently inserted in polybags with out damaging the bud keeping the upper most bud exposed and finally these bags placed in the polyhouse.
- The insertion/plantation of cuttings should be done during the last week of March to first week of April.
- Optimum hygrothermic conditions viz, 25 – 30⁰C temperature and 75 – 80 % humidity should be maintained in polyhouse.
- Irrigation should be carried out as and when needed. However there should be proper drainage of water from the polybags as otherwise the saplings would decay.
- Fertigation should be carried out after 40 days.
- After 75 to 90 days saplings should be transplanted to the main field and planted at a distance of at least 9" x 9".
- Immediately after transplantation sufficient irrigation should be given to enable saplings to get established. Since the ambient temperature is more, frequency of irrigation should be maintained as per requirement. In addition, the field/nursery should be kept weed free as far as possible.

Since every part of the mulberry plant finds use in one way or the other, as such mass multiplying of plants and their subsequent plantation will not only make available more quantity of leaf in less possible time for increased cocoon production but also result in value addition of the sericulture industry through intercropping of different vegetables with mulberry, multiple cocoon crops etc.



Fig:-1. Just planted mulberry cuttings in polybags



Fig:-2. Sprouted mulberry cuttings in polybags



Fig:-3. Lush growth of mulberry saplings in nursery

CHAPTER 4: AVENUES AND OPPORTUNITIES IN SERICULTURE

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INTRODUCTION

The Livelihood of the majority of the population of the Jammu & Kashmir State revolves around the agriculture and allied sectors. These sectors constitute the mainstay of the state's economy and contribute nearly 50 per cent to GSDP. Over 80 per cent of the population of this state depends, directly or indirectly, on agriculture. But fact of the matter is that agriculture in the hills and mountains of the state suffers from inherent constraints of remoteness and inaccessibility, marginality and fragility in terms of moisture stress and poor soil conditions and a short growing season. Hilly and inaccessible terrain in the state constrains the introduction of mechanized farming and hassle free transportation of inputs and products. Besides, being prone to soil erosion due to fragile soil, the hilly areas are also not amenable to multiple cropping, thus, impeding the uptake in the production and productivity in these areas. If such bleak and dismal agriculture scenario continues for sometime more, malnutrition and hunger is eminent. In order to contribute to otherwise receding income of the farmers, adoption of multidisciplinary income augmenting ventures is of paramount importance which will not only go in a long way to increase the better livelihood earnings but will definitely improve the socio-economic status of farmers. One such venture which not only is women friendly, but also fetches quick returns to the farmers comparatively at a greater ease, is sericulture-the practice of silkworm, *Bombyx mori* rearing for production of cocoons which finally yields splendid fabric of high elegance and drupability.

Sericulture is practiced in 52,360 villages all over the country (Bharathi, 2016). At present, the raw silk production of India is 28,708 MT while the domestic demand is 32000MT (Anonymous, 2016). Thus, there is scope for production of additional quantity of quality silk in the country to meet the domestic demand.

Jammu and Kashmir is the traditional sericulture state of India where sericulture is practiced in 20 districts. The major silk producing districts are Anantnag, Kupwara, Pulwama, Bandipora, Baramulla, Ganderbal, Udhampur, Rajouri, Reasi and Kathua. Kashmir silk is considered of very high quality as per the international quality standards. Presently, about 30,000 rural families are directly or indirectly associated with the silk industry and are generating an income of Rs.2026.00 lakhs annually (Anonymous, 2015). The cocoon and the raw silk production in J&K during 2014-2015 were 1032.4MT and 138 MT respectively (Sahaf *et al.*, 2016, Chouhan *et al.*, 2016) which is much less than the capacity and scope of silk production state has.

REASONS FOR FLUCTUATING PRODUCTION IN INDIA

- Urbanization in traditional silk producing states
- Fluctuation in market prices of mulberry commercial cocoons
- No substantial increase in the price of cocoons and the silk over a decade as compared to other agricultural crops
- Inflow of chinese silk to Indian market through various ways
- Scarcity of agricultural labour
- Erratic rainfall in sericulture areas

REASONS FOR CHINA BEING TOP RANKED IN SERICULTURE

- Strict maintenance of discipline
- Better linkage from farmers to weavers
- Large-scale operation of egg production,
- Reeling and weaving using modern machineries
- Strict control measures for diseases
- Uniform adoption of new technologies
- Supply of required quantity of quality eggs in time to avoid the chances of contamination of young silkworm etc.

EMPLOYMENT POTENTIAL IN SERICULTURE

Sericulture is highly remunerative & employment generating occupation. It is estimated that employment generation is 11 mandays/Kg of raw silk production in India. In China 20 million farmers & 5 lakh people are occupied by sericulture & silk processing industry. 52360 villages in India providing employment to 6 million people from the farm sector and silk processing industry. During 2015-16, employment in sericulture was 72.5 lakh persons as against 68.17 lakh persons during 2009-10.

PROBLEMS OF SERICULTURE IN J&K STATE

- Knowledge deficit among farmers
- Farmers conduct rearing in dwelling houses .
- They are reluctant to disinfect their houses properly.
- Unhygienic methods of rearing
- Poor quality of mulberry leaf harvested from scattered unmaintained age old plants of inferior genetic stock.
- Silkworm rearing a part time activity-only a single crop is raised
- Silkworm seeds are distributed more than the requirement as per reports.
- Most of the farmers are supplied incubated seed only and not the chawkie worms.
- Farmers use neither stands nor trays for rearing silkworms and rear them either on floors or temporary shelves under crowded conditions.
- Spinning of cocoons is not done properly and sun drying of cocoons is very common.
- Mounting material is of poor quality.
- Weak sericulture Extension mechanism
- Poorly developed weaving and reeling sector.

- Marketing facilities are not adequate.
- Inadequate and unskilled human resource
- Incomplete value addition

INITIATIVES TAKEN FOR PROMOTION OF SERICULTURE IN J&K

- 1. Development of high yielding silkworm genotypes:** This is the basic requirement for successful sericulture. In this endeavor TSRI Mirgund evolved 20 new and more productive breeds from some exotic hybrids. Two of these breeds SKAU-R-1 and SKAU-R-6 (in form of hybrid) designated as SKAU-HR-1 was authorized earlier for commercial exploitation in temperate areas of the country by Residual Race Authorization Committee of CSB, Ministry of Textiles, GOI.
- 2. Improved methods of silkworm Rearing :** One of the limiting factors for the progress of sericulture in our state is the knowledge deficit among the farmers regarding improved methods of silkworm rearing. TSRI, Mirgund is demonstrating all the improved methods of silkworm rearing at the farmer’s field by carrying out rearing at their places and through village adoption.
- 3. Popularization of Low cost Technologies in the Field:** To address the problem of inadequate rearing accommodation at farmer’s level, TSRI Mirgund designed and fabricated a low cost rearing hut with dimensions of 15x12x8 and the capacity to produce 60 Kg of cocoons per ounce of silkworm seed. The hut is constructed from the locally available material and is also cost effective.
- 4. Raising of Mulberry Under Poly house:** To address the problem of in-sufficient mulberry plants in the state , TSRI Mirgund developed a low cost polyhouse technology for the efficient rooting of poor rooting mulberry genotypes. This zero energy poly house technology enhances the rooting ability of poor rooting varieties like Goshierami (commonly available variety in field), Ichnose and KNG from 10-15 percent (by grafting method) to 65-70 percent (by the new technology) & ensures 100 percent availability of true to the type plants to the farmer in shorter duration (2 years) as against 5 years (by grafting method).
- 5. Introduction of Some New Mountages :** TSRI, Mirgund has earlier introduced many locally available mounting materials which farmers are using at present for seriposition of silkworms. These include rapeseed hay (*Brassica campestris* L.) ,hackberry (*Celtis australis* L.), flex weed (*Descurina sophia*), goose-foot (*Chenopodium scoparia*), indigofera shoots (*Indigofera haterantha*), pine shootlets (*Pinus excels* Wall) and Paddy straw (*Oryza sativa* L.). In addition to above TSRI also developed three modified mountaged namely rotary mountage ,Mounting-frame and Plastic-frame. All the above mountages were evaluated and highest cocooning percentage (95.56%) was achieved in rotary mountage followed by Mounting-frame and Plastic-frame (94.22% and 93.27% respectively). Minimum cocooning percentage was recorded in plastic collapsible mountage

6. **Development of Value added products:** To improve the returns of a farmer practising sericulture value added products of mulberry viz., Mulberry Jam, Mulberry Syrup, Mulberry tea, Mulberry feed block and Cocoon Crafts were developed at TSRI to augment the income of the farmers. Based on the highly satisfactory performance, Mulberry Jam & Syrup was marketed by the state Agro Industries under the name SNOW KIST.
7. **Utilization of by products of Silkworm Rearing:** Mulberry silkworm pupae, one of the major by products of silk industry have been used as a feed for poultry and trout fish by this Institute. This was considered as a waste in silk reeling units and silk producers after reeling out silk used to throw the dead pupae at the out skirts of their reeling units, creating nuisance and health hazards. This Institute has used silkworm pupae as a source of protein for animal feed (trout fish and poultry).
8. **Introduction of Sericulture in the remote and farflung areas of our state:** Expansion of mulberry sericulture to the new and unexplored border areas of the state assumes a greater significance by way of providing a source of sustainable livelihood to the poor and disadvantaged sectors. Among the various border areas of the state, Gurez and Ladakh situated at the high altitudes of the state of Jammu and Kashmir are extremely important from the defense point of view, where people deserve due attention to improve their livelihood on sustainable basis. The scope of growing horticultural and agricultural crops is limited in these areas and roads also remain closed for more than six months in view of heavy snowfall and other climatic vagaries. Under these conditions sericulture alone has the potential to improve the livelihood security and socio-economic status of the people of these areas besides helping in conserving environment.
9. **Generation of trained human resource:** At present no institute in the country is conducting Resident Instruction Programme specific to temperate bivoltine sericulture. TSRI, Mirgund is the only in the country who Generate qualified and trained human resource in order to give boost to the production and productivity of silk in the country.
10. **Opportunities for Sericulturists in Academic Fields:** A well qualified Sericulture graduate/Post graduate has the opportunity to get absorbed in different departments in different capacities like Assistant Professor/Lecturer (Sericulture) in colleges and Universities, Instructor (Sericulture), Lab Assistant, Sericulture Assistants, Deputy Director Sericulture, Seed examiners etc. One can also get jobs in central govt agencies like CSB/Silk Export promotion Council/NABARD/KVKs, Development Officer in State / District Khadi Board, Agriculture Field officer in Banks and Handicraft Training officers.

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CHAPTER 5: AGROFORESTRY AND SCOPE OF MULBERRY UNDER THE SYSTEM IN KASHMIR VALLEY

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Land is a vital natural resource and is the basis of our existence. Due to mounting pressure of increasing human and livestock population which at present stands at 125 and 159 lakhs respectively it has been subjected to various pressures and misuse resulting in degradation of land and loss of biodiversity. Management of land is therefore, of paramount importance so that increasing needs of human and livestock are met on sustainable basis. Demand of food, fodder, fuel wood and timber like in other parts of the country is on an increase in J&K state also there is huge gap between the demand and supply.

Food grain requirement of Kashmir valley during 2010-11 stood at 1.34 million tones and the availability was only 0.45 million tones. Deficit during the year stood at 0.98 million tonnes (Trag and Rather,2013).

The average production of timber from state forests has been around 80,000 cubic m. while as the annual demand of timber in the state can roughly be estimated around 5.80 lakh cubic m. Hence there is a huge gap between demand and supply of timber. This demand is partly met from trees outside forests (3.80 lakh cubic m) and partly from the imports of timber (1 lakh cubic meters) from outside thereby leaving a gap of about 20,000 cubic m (Anonymous, 2012).

Similar situation exists on fuel wood and fodder front. The estimated total consumption of fuel wood as per the FSI report is 10 lakh tones and the departmental production on an average is only 1.5 lakh tones per year. FSI report 2011 has estimated annual production of fuel wood to the tune of 2 lakh tones from state forests and 3.65 lakh tones from trees outside forests thereby leaving huge gap to be bridged.

Fodder demands for an estimated 10.99 million live stock in J & K is also on an increase. Forests provide approximately 25 lakh tones of fodder annually while as the demand stands at 94 lakh tones. This gap in demand and supply is filled by the supplies from agricultural crop residue and also imports from neighbouring states. Forests cannot meet all these demands of timber, fuel wood and fodder on a sustained basis as they are not in a healthy state In the cultivation area

major portion is under dry farming and in J&K cultivation can be resorted to any degree of slope without regard to any conservation practices, as such these areas are subject to very high rate of erosion. In order to bridge the gap between demand and supply of food, fodder, timber and fuel wood various options available are:

- Increase in area under different land use systems.
- Breeding for higher yield and use of high yielding varieties
- Increased use of fertilizers, insecticides and pesticides.

Under the present circumstances it is not possible to increase area under different land use systems because of various pressures on land viz. road construction, development of infrastructure, construction of dams and hydroelectric projects, railway projects etc. High yielding varieties due to increased use of fertilizers, insecticides and pesticides have already polluted our land, water and air. Therefore, under the present scenario the only option available is Agroforestry or multiple land use system. During the last three decades agroforestry has been recognized as a distinct land management system, which is destined to play an important role in socio-economic transformation of marginal lands into more productive agrarian economy.

Agroforestry is a concept which has been in force from decades in which trees, crops and animals have been reared by the farmers on the same piece of land generally known as farms. It was only with the emergence of separate departments of agriculture, horticulture, forestry and animal husbandry that, they began to be managed and looked after by their own department separately, which previously used to be managed collectively under agriculture. Agroforestry has arrived and became firmly established as a term and concept in International development and rural science terminology in a surprisingly short time.

Agroforestry Defined

Defined as a sustainable land Management system which increases the use of land, combines the production of crop and forest plants and or animals simultaneously or sequentially, on the same unit of land and applies management practices that are compatible with the cultural practices of the local population (King, 1987).

Definition of agroforestry outlines the broad boundaries of agroforestry and the typical characteristics of such system are:

- Agroforestry normally involves two or more species of plants at least one of which is a woody perennial.

- Agroforestry system always has two or more outputs.
- Cycle of agroforestry is always more than one year.
- Even the most simple agroforestry system is more complex, ecologically and economically than a mono cropping system.

Agroforestry systems vary considerably in their structural complexity and species diversity productive and protective attributes and socio economic dimensions, we have simple form of

- Shifting cultivation
- Sophisticated hedge row intercropping
- Spare stands of trees on farms
- High density complex multistoried home gardens of Humid low lands

In India also agroforestry practices are ancient but the story of organized agroforestry research began in 1979 at Imphal, when a seminar on agroforestry was organized by ICAR, New Delhi to accumulate and compile data on research and development of agroforestry Research in India.

Thereafter, as a follow up action ICAR launched All India Coordinated Project on Agroforestry in 1983 at 20 centers across India, of which 12 centers were located in State Agricultural Universities and 8 at ICAR Institutes. Later on more centers were included and at present there are 37 centers, 27 in State universities and 10 in ICAR institutes representing all the agro climatic regions of the country.

The state of Jammu and Kashmir, especially the valley of Kashmir, has a rich diversity of traditional Agroforestry models, which are in existence since time immemorial. Agroforestry over here is based primarily on natural occurrence of trees. These traditional agroforestry practices have to some extent, helped people in meeting some of their diverse needs i.e. food, fodder, fuel wood and timber. Presently agroforestry systems meet about 3.65 lakh tones of fuel wood and 3.80 lakh m³ of timber in Jammu and Kashmir.

Traditional agroforestry systems of Kashmir valley

(Mughal and Khan, 2007)

1) Boundary Plantations

This oldest traditional model is practiced on plain paddy fields. Farmers generally do not plant any tree within the paddy fields, but if the same land lies besides a road then people plant trees on the road side. In addition to this if a canal passes through the farmers land, then on both sides of the canal farmers plant *Salix* trees. Other trees raised are *Populus deltoides*, *Populus nigra* and *Aesculus indica* and the spacing is maintained at 1.20x1.20m. This model is adopted by marginal as well as small and big farmers. *Avena sativa* and *Brassica spp.* are grown during

winter. These lands suffer from impended drainage and are not suitable for any other agricultural crop except paddy during summer.

2) Agrisilviculture on sloping lands

This system is practiced by people residing on the mid mountains or at the foothills of mountains. These hilly areas are completely devoid of vegetation and suffer from scorching heat during summer and lack of moisture in the months from May onwards till winter sets in. People raise forest tree species around their farms, which serve as boundaries as well as provide much needed fuel and fodder. Sometimes trees may be found scattered inside the farm area also. Amongst the agricultural crops maize is raised as monoculture as it can survive under moisture stress conditions compared to other crops. During winter, mustard and at some places vegetables like brassica, carrot, reddish, turnip etc are grown. Trees planted by the farmers in these land are *Robinia pseudoacacia*, *Ailanthus altissima*, *Aesculus indica*, *Populus nigra*, *Salix alba*, *Ulmus wallichiana* and *Juglans regia*. Except for *Juglans regia* spacing of trees is maintained at 1.20x1.20m. Problems of the area include lack of water in streams during summer, exposed denuded surface and low agricultural output.

3) Agrisilviculture in Hills and Forests

This type of agroforestry system is practiced in the hilly areas and in the forests. People in these areas live in the vicinity of or in the forests. The forests in the region are composed of evergreen trees in the form of deodar, kail, fir and spruce besides, some broad leaved species like poplars, willows, elm are also found in the area. The farmers generally grow maize in the summer season, while during winter oil seeds are raised. In some areas different vegetables are also grown for local consumption.

4) Agrisilviculture in flat or plain lands

The land in plain areas is fertile and very well suited for agriculture. Farmers whether marginal or small keep a separate area within the paddy fields of the size of about 500-600m² which is generally raised in comparison to paddy field. This area is kept surrounded by tall trees of *Populus deltoides*, *Populus nigra*, *Salix alba* and sometimes *Robinia pseudoacacia* and the spacing is very close. Some trees are kept scattered within the farm also. Vegetables are grown both in rabi as well as Kharif seasons. Rabi season vegetables include knol khol, cabbage, cauliflower, turnip, radish, carrot, onion, peas, spinach, garlic etc. In karif season vegetable like tomato, brinjal, chilies, capsicum, french beans, cucumber, bottle gourd, bitter gourd, pumpkin, potato etc, are grown

5) Hortisilviculture

This system is practiced on slopes with or without irrigation facility. The main purpose of the system is the production of fruits for marketing. Fruit trees are grown at regular spacing within

the farm at a spacing ranging from 3x3m to 3.5x3.5m depending upon the fruit tree species. Forest trees are grown on all the four sides of the orchard in single or double rows along the boundary. The trees are planted at a close spacing of 1.2x1.2 m and the purpose of growing these trees is wood for packing of fruit, timber for construction and fuel wood production. Forest trees species raised are *Aesculus indica*, *Ailanthus altissima*, *Populus deltoides*, *Populus nigra*, *Salix alba*, *Robinia pseudoacacia*, and *Ulmus wallichiana*. Fruit trees include *Punica granatum*, *Juglans regia*, *Prunus cerasus*, *Prunus amygdalus* (Almond), *Malus pumila* (Apple) etc.

6) Hortisilvi pasture

This system is practiced on sloppy lands but in some cases it has been observed in orchards located on plain lands. The system has all the components of hortisilviculture as listed above and in addition pasture grasses (*Festuca pretense*/ *Dactylis glomerata*), legumes (*Trifolium pretense*/ *Trifolium repens*) or *Avena sativa* are also grown in these orchards when the fruit trees are in juvenile stage. *Avena sativa* is grown during winter as there is no shading effect on the crop during winter.

7) Hortisilviagriculture

This system is practiced in places where orchards are located either on terraces or flat lands with irrigation facility throughout the year. In this system people devote a little area within the orchard for raising vegetables during Rabi and Kharif season for domestic consumption. The vegetables are intercropped between fruit trees whose spacing is maintained at 6x6m and the vegetables grown are knol khol, cabbage, cauliflower, turnip, radish, carrot, onion, peas, spinach, garlic, tomato, brinjal, chilies, capsicum, french beans, cucumber, bottle gourd, bitter melon, pumpkin, potato etc. Trees and fruit components are same as that of hortisilviculture. Earlier the problem with the system was that people used to raise vegetables in the small area for domestic consumption only while as the rest of the area is not utilised for agriculture, but with the passage of time some farmers in North Kashmir are now utilizing the whole orchard for raising vegetables for commercial purposes.

8) Kitchen gardens

Kitchen gardens or multistoried homesteads are found throughout the valley and is generally common among those farmers who have a land holding of about 500-1,000m² located just around their residence. On the piece of land people raise fruit trees and vegetables of all kinds during Rabi and Kharif season. Poultry is also reared on the same piece of land. Besides, people raise tall trees of *Populus deltoides*, *Ulmus wallichiana* or *Salix alba* along the boundary in single or double rows in close spacing. Fruit trees may consist of pomegranate, apple, cherry, peach, plum, almond, queen apple etc. Sometimes all the fruit trees may be found growing in the kitchen garden. Vegetables are grown in interspaces of fruit trees and may include cabbage, turnip, radish, carrot, onion, peas, brassica etc.

Traditional Agroforestry systems in Ladakh region

1) Boundary plantation (Agrisilviculture)

In Ladakh region, diversity of tree species is very limited. Poplar and willow are the main timber trees grown under agrisilviculture system. There are about 20 species of local willows and 10 those of poplar growing at different attitudes of Ladakh. Out of them, some worth mentioning are : *Populus nigra*, *P alba*, *P ciliata*, *Salix alba*, *S. excelsa*, *S. angustifolia*. The trees are grown along the boundaries of the field at a very close spacing of about 1x1m. Agricultural crops like wheat, barley, mustard buck wheat and pulses are grown in the rest of the field either in monoculture or in combination.

2) Silvipasture

Under silvipasture a leguminous plant alfalfa (*Medicago sativa*), is grown in the dense plantation of poplar (*P. nigra* var *italic*) locally known as yulat. This system of agroforestry is very popular in Ladakh region.

3) Hortipastoral system

Apple and Apricots are the major fruit trees grown and the interspaces are cultivated with perennial grass of alfa alfa.

4) Hortiagriculture

Apricot or apple orchards where the spacing is maintained at 3.5x3.5m are also cultivated with wheat or barley during summer months

5) Kitchen garden

Kitchen gardens are found in the vicinity of the residential areas. The garden is surrounded by tall trees of poplar or willows. Vegetables like brinjal, tomato, peas, onion, garlic, spinach and pulses are grown in kitchen gardens during summer months. Some trees of apricot or apple may also be found scattered in the kitchen garden

Agroforestry Management Studies in Kashmir valley

Source: Anonymous (2002-06)

Bio economic productivity of Agri - Silviculture system integrating *Ulmus wallichiana* with field crops and grasses.

Under the system during the period under report 2002-06 a number of field crops were tried and evaluated in terms of yield & income generated from crop combinations.

The combinations tried were peas& potato, garlic & potato, garlic & maize and lentil & maize. Tree spacing of 2.0 m alley resulted in maximum yield of crops as well as maximum income

Income generated (profit) under 2 m alley during different years

2001-02	Rs. 57,107.00 ha ⁻¹ for Peas & Tomato
2002-03	Rs. 63,386.44 ha ⁻¹ for Peas & Potato

2003-04	Rs. 80,466.16 ha ⁻¹ for Garlic & Potato
2004-05	Rs. 44,554.95 ha ⁻¹ for Garlic & Maize
2005-06	Rs. 9,968.60 ha ⁻¹ for Lentil & Maize (Fodder)
2006-07	Rs. 26,948.00 ha ⁻¹ for Mustard & Rajmash

Growth and biomass productivity of *Populus deltoides* and *Catalpa* in association with red clover

Source: Anonymous (2002-06)

The data indicated that the Poplar trees recorded increase in height and collar diameter in combination plots. Also the biomass recorded from tree components also recorded substantial increase over sole crop

However, the yield of grasses was found decreasing in combination plots

The increase in height and dbh of trees in Poplar + grass plots was observed 43 % and 49 % more respectively. The total biomass yield (fodder+ fuel wood) was observed 90. 24 and 24.1% more in Poplar + grass and Catalpa + grass as compared to pure tree plots of Poplar and Catalpa

Yield of red clover was found decreasing in combination plots, 5.79% in Poplar + grass and 23. 25% in Catalpa + grass

Height, diameter and biomass (Fodder + Fuel wood) of trees in Silvi pasture system (2005-06)

Treatment	Mean height (m)	Mean dbh (cm)	Fodder (q/ha)	Fuel wood (q/ha)	Total biomass (q/ha)
Populus	6.89	5.09	6.42	10.25	16.67
Catalpa	4.58	4.84	7.63	12.36	19.99
Populus + grass	9.91	7.59	11.49	20.49	31.83
Catalpa + grass	4.81	5.60	8.65	16.14	24.79

Treatment	Yield of Grass- red clover (q/ha)
Populus + grass	45.0
Catalpa + grass	36.66
Grass	47.77

Restoration of unproductive land resources through silvi pasture system

Mughal *et al.*, (2003)

Silvipasture experimental trial with oats (*Avena sativa*) and M . P. Chari (*Sorghum vulgare*) was evaluated on degraded lands for a period of 5 years with *Amorpha fruticosa* a nitrogen fixing shrub.

The results revealed that yield of forage crops recorded an increase as their distance from the tree component increased

Tree component was benefited in combination plots in terms of height and diameter. Combination plants recorded a land equivalent ratio of 1.63 at 2 m distance from the tree.

The results further reveal that for making the model viable and for yield maximization a distance of 4m x 4m should be maintained for the tree component.

Morus (Mulberry) A multipurpose tree specie for agroforestry

Morus belongs to family Moraceae and comprises of about 10–16 species of deciduous trees commonly known as mulberries, growing wild and under cultivation in many temperate world regions. It is known by different names in the different regions of the world and the country as under:

Arabic (Tuth); Bengali and Hindi (Tut); Burmese (Posa); English (Mulberry), Kashmiri (Tul)

BOTANIC DESCRIPTION

Morus is a fast-growing shrub or moderate-sized tree. Cylindrical straight bole, up to 35 m high and 1.8 m in girth. Bark dark greyish-brown, rough with vertical fissures; exuding white or yellowish-white latex. Leaves very variable, ovate or broadly ovate, distichous, simple to 3-lobed, 3-veined at base. Flowers are normally bisexual but can be unisexual on different branches of the same plant. Fruits Catkins appear in April and May. Fruit ripens and drops off the tree from June to August. Dispersal is by water, birds, jackals and human beings.

ECOLOGY

Morus grows in areas with a subtropical or mild temperate climate. It is a shade tolerant tree and grows up to 3300 m altitude. It can tolerate a mean annual temperature 0-43⁰C and mean annual rainfall of 1500-2500mm

SOIL TYPE

The plant grows on a variety of soils ranging from sandy loam to clayey loam, but prefers deep, alluvial, loamy soil with sufficient moisture and pH 6.0-7.5

Strengths of Mulberry as an agroforestry tree

- Ease of propagation both sexually and asexually
- Easily transplanted in the field
- Fast growth and early establishment
- Nutritious and easily harvestable fruits
- Regular fruit bearer
- Long fruiting season
- Unusually resilient in that they fruit in years where frost kills early buds Has both primary market as a food crop and a secondary market in cocoon rearing
- Rot resistant wood means use for fence posts while smaller branches are great fire wood
- Susceptible to caterpillars in the right conditions but rarely are damaged and yield with no spraying.
- Long history of breeding and cultivation has passed the experimental phase of development

Multiple Utility

- **Food:** Leaves are highly nutritious and contains vitamin B complex (except B12), C (200-300 mg/100 g), and D. They are sometimes eaten as a vegetable; fruit is eaten fresh or made into juice and stews.
- **Fodder:** Leaves are used as fodder for livestock; up to 6 kg of leaves a day can be fed to dairy cows to improve milk Yield.
- Shade-dried leaves incorporated into feed enhance health and egg production in poultry.
- **Fuel:** Makes medium-quality fuel wood with a calorific value of 4370-4770 kcal/kg
- **Fibre:** Wood yields sulphate pulp with satisfactory strength for white writing and printing paper; bark is worked in to paper pulp and fibre is suitable for the textile industry.
- **Timber:** M. alba yields a medium-weight hardwood with a density of 670-850 kg/cubic m. Heartwood yellow or yellowish brown, darkening to golden or red-brown upon exposure, sharply demarcated from up to 4 cm wide; white or pale yellow
- It is easy to saw, work, turn, bend and finish, and it seasons well. It is suitable for house building, boats, beams, posts, flooring, bridge building, agricultural implements, cabinet work, furniture valued for sports equipment such as hockey sticks, tennis and badminton rackets, and cricket bats

Eco system Services

- **Erosion control:** A useful species for stabilizing physical soil-conservation structures
- **Shade or shelter:** Recommended for shelter planting such as protecting orchards from wind
- **Reclamation:** Grown on wastelands
- **Soil improver:** The species helps in maintaining soil fertility through litter fall; lowers soil surface temperature
- **Ornamental:** Grown on roadsides and avenues as an ornamental tree

Sericulture-based agro forestry systems for hilly areas of north-east India

S. K. Dhyani *et al.*,1996

Sericulture-based agroforestry systems (AFS) have great potential for higher returns in the north-eastern region with sloping and valley-land conditions

Seven mulberry (*Morus alba* L.) varieties, seven silkworm breeds and rearing performance of a bivoltine breed, NB-18 were evaluated in different trials

Three sericulture-based AFS viz. sericulture with 1. fruit trees and fodder grasses, 2. field (upland) crops, and 3. lowland rice were developed at the Research Farm

Mulberry varieties TR-4, S-1635 and TR-10, and NB-18 — a bivoltine silkworm breed were found better suited for this region

Sericulture with field crops (French bean-groundnut-mustard/vegetables) for valley land, with fruit plants (guava, pineapple) and grasses for mid-hill situations, and with rice for low lands were found suitable at the Farm and for possible adoption in the north-eastern hill region of India.

Agroforestry systems in Himachal Pradesh

(Verma *et al.*,2007)

- Zone I Sub tropical sub montane and low hills Up to 919m
- Zone II Sub temperate sub humid mid hills 915-1523 m
- Zone III Wet temperate high hills 1524-2472m
- Zone IV Dry temperate high hills >2472 m

In agro climatic zone I & II *Morus laevigata* is one of the species used as fodder tree under agro forestry systems and is used for fodder, small timber and agricultural implements

In wet temperate Zone III high hill *Morus serrata* is the most favoured species. Maize, wheat, barley, buck wheat and millets are the major cereals. Beans tomatoes and potato constitute the main vegetable crop

In sub tropical sub montane low hills the forest tree species include *Morus alba* in combination with fruit crops like mango, guava and citrus thus forming silvi horticultural system

Mixed Farming in South India

Mulberry can be successfully grown as an inter-crop (medium mixed tree) between the rows of tea/coffee as shade plants. By this besides providing shade to the tea/coffee plants, good quantity of quality leaves can be obtained for silkworm rearing and as feed for cattle and goats. Further, the pruned shoots are a good source of firewood.

Mulberry can also be grown as an inter-crop for cultivation in the wider space existing between sources of coconut plantation. A survey has shown that mulberry is inter-cropped with coconut in Channapatna, Ramanagaram, Kanakapura and Bangalore areas of Karnataka state.

Agroforestry tree species identified during survey in Kashmir valley

Following 12 multipurpose tree species having agroforestry promise have been identified during the survey along and their use

S.No	Species	Method of planting	Use				
			Fruit	Fodder	Fuel wood	Timber	Soil conservation
1	<i>Aesculus indica</i>	D.S	No use	Good	Better	Best	Satisfactory
2	<i>Ailanthus altissima</i>	D.S	No use	No use	Satisfactory	Good	Best
3	<i>Juglans regia</i>	D.S	Best	No use	Occasional	Best	Good
4	<i>Morus spp</i>	E.P	Best	Good	Best	Good	Better
5	<i>Populus spp.</i>	B.P	No use	Good	Good	Better	Satisfactory
6	<i>Prunus armeniaca</i>	D.S, E.P	Best	Good	Best	Good	Best
7	<i>Prunus cerasus</i>	D.S, E.P	Best	Good	Best	Good	Better
8	<i>Prunus persica</i>	D.S, E.P	Best	Good	Best	Good	Better
9	<i>Pyrus communis</i>	E.P	Best	Good	Best	Good	Better
10	<i>Robinia pseudoacacia</i>	R.S	No use	Best	Best	Good	Best
11	<i>Salix spp.</i>	B.P	No use	Best	Better	Better	Poor
12	<i>Ulmus wallichiana</i>	E.P	No use	Best	Best	Good	Better

D.S= Direct sowing; E.P= Entire planting; B.P= Branch/ cutting planting; R.S= Root sucker

Effect of leaf leachate of *Morus alba* on different pulse crops

Mughal, (2000)

Laboratory study was conducted to see the allelopathic effect of leaf leachate concentrations of *Morus alba* L. on germination and seedling growth of pulses Peas (*Pisum sativum*) Lentil (*Lens esculenta*) and broad beans (*Vicia faba*).

Both stimulatory as well as antagonistic effects on all the recorded parameters i.e. germination root length, number of secondary roots, shoot length and vigor index were recorded

In peas and broad beans up to 50% concentration of leaf leachate there was a stimulatory effect on all the recorded parameters while beyond 50% leaf leachate concentration there is an antagonistic effect on the recorded parameters expect for germination in broad beans.

In lentil leaf leachate concentration up to 25% stimulated the germination and seedling growth but beyond 25% antagonistic effects were recorded.

Intercropping with mulberry

Source: TSRI

For improving land use efficiency, generate additional income and improve farmers security intercropping with agricultural crops during rabi and kharif seasons is imperative

Kharif crops			Rabi crops		
Crop	Sowing time	Harvesting	Crop	Sowing time	Harvesting
Rajmash (Beans)	April to June	Aug. Sept	Turnip	August	Oct.- March
Leafy vegetables	May-June	Aug. - Sept.	Leafy vegetables	September	Oct. - March
			Onion/ Garlic	November	May- June

Besides getting revenue from rearing of silk worms , a farmer can earn additional income of Rs.50,000 to 75,000/ha/yr from intercropping

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CHAPTER 6: SILKWORM REARING TECHNOLOGIES.

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INTRODUCTION:-

Sericulture is one of the oldest agro-based rural industry of Jammu and Kashmir. The state has a long history of producing quality Uni / Bivoltine silk, as the salubrious climate prevalent here is ideally suited for the luxurious growth of mulberry and silkworms. However, present scenario of this traditional industry is not so encouraging. Besides many other factors the lack of technical know-how of farmers particularly in Kashmir region is one of the major factors, which is responsible for the decrease of cocoon crop in the region. The state being a traditional bivoltine sericulture-practicing region has not picked up as expected during the last 2-3 decades. The conventional practices in silkworm rearing are so deep rooted among the farmers of the region that they are reluctant to adopt the new technologies and as a result are not able to produce better cocoon crop in terms of quality and quantity. In order to visualize the benefits of modern technologies by increasing productivity of cocoons and also bringing improvement in their quality. Various *Silkworm Rearing Technologies have been developed* by Temperate Sericulture Research Institute, Mirgund, SKUAST-K which are implemented in the adopted villages in collaboration with Sericulture Development Department J&K. In the first instance these technologies were implemented in various villages and recently in Rambail village of tehsil pattan during 2016 and 2017.

TECHNOLOGIES FOR SUCCESSFUL COCOON HARVEST

Under this programme the following technologies were demonstrated/transferred to the rearers for maximizing quality cocoon production: -

- Quality mulberry leaf production technology.
- Effective disinfection of rearing accommodation and equipment using latest disinfectants.
- Technical guidance from concerned scientists during Incubation, black boxing and Chawki rearing.
- Adult age rearing with recommended package of practices.

- Maintenance of hygienic conditions within and around the rearing space.
- Use of various bed disinfectants as per recommendations.
- Use of Phtoeecdysteroid for synchronization of maturation.
- Utilization of locally available recommended mounting materials for harvesting quality cocoon crop.
- Care taken during seriposition for reducing mortality.
- Harvesting, Sorting, Drying and Storing of cocoons for maintaining quality.
- Marketing of cocoons for getting remunerative price.

AVAILABLE TECHNOLOGIES

1.INCUBATION AND CHAWKI REARING:-

Incubation is the process of providing optimum environmental conditions to silkworm seed in order to get maximum and uniform hatching on a particular day.

The silkworm seed is the basic input for the Sericulture Industry. The crop performance and silk productivity are directly related to the quality of seed. The quality of silkworm seed can be considered as eggs produced from good cocoons under optimal environmental conditions and free from diseases.

The quality of seed has to be retained by adopting proper egg handling techniques. Quality can deteriorate due to improper handling during its processing, preservation, hibernation, acid treatment, chilling, incubation, transportation etc.

Incubation is one of the most important techniques in seed handling. The term “Incubation in Sericulture is used with reference to provision of optimum environmental conditions (Temperature $25 \pm 2^{\circ}\text{C}$, $75\% \pm 5\%$ rH , photoperiod of 16L: 8D, Air current 0.3 mm/sec) for the proper and uniform development of the silkworm egg .The term incubation is used specifically for these eggs, which are naturally active or artificially activated eggs and not to those eggs, which are kept under aestivation, though the provision of environmental temperature and humidity are similarly to that of the eggs under incubation. Thus, incubation of silkworm eggs in conducted under manipulated environmental conditions, which enables the silkworm eggs to develop normally and hatch as healthy larvae with maximum hatchability on the expected day.

BLACK BOXING: -

Incubation being an important seed handling activity should always be followed by black boxing technique. The technique provides synchronized hatching in a short period of time. The eggs, which are not black boxed, hatched irregularly over a period of time, and this can be attributed to many factors, such as weight of eggs and the oviposition period, which stretches from 24 to 48 hours.

In order to obtain synchronized hatching in a short period of time photoperiod is manipulated. Particularly in later stages of development, i.e. eggs on reaching pinhead stages (head pigmentation stage) are subjected to complete darkness and exposed to light after 48 hours. This method is adopted to make use of the well known fact that the development of embryos are faster and uniform in light upto pin-head stage and darkness enhances uniform development from pin head stage up to the outset of hatching and light stimulates hatching. This method of providing complete darkness to the eggs from pinhead stage (head pigmentation stage) to outset of hatching is called as “BLACK BOXING TECHNIQUES”. Photoperiod during incubation not only affects the growth and development of the embryo but also plays an important role on the voltinism of the race. Bivoltine eggs incubated in complete darkness i.e. 16 hours dark: 8 hours light produce moths, which lay non hibernating eggs and those eggs, which are incubated in complete light i.e. 16 hours light: 8 hours darkness produce moths that lay hibernating or diapausing eggs. This clearly suggests that photoperiod effect, the physiology of the developing embryo. The most critical stage of the embryo, which is sensitive to photoperiod, is from the stage of appearance of thoracic appendages. Complete darkness is a basic requirement for this technique as 5 lux of light is sufficient to stimulate hatching.

CHAWKI REARING:-

The rearing of first two ages is called chawki rearing or young age rearing. The temperature of 28 and 27 is maintained in these two ages. Tender leaf having moisture more than 80% is best for these ages. Proper care is to be maintained in these ages so that late age rearing becomes successful.

2) LATE AGE REARING :-

Late age rearing was done on floor as well as on shelves by the rearers. Since the inception of silkworm rearing in the state, rearers are practicing shoot rearing method of feeding

which is popularly known as “*Bachi System*”. However the rearers used to put these branches in a haphazard manner on the rearing bed as such making this leaf inaccessible to all the worms uniformly in the bed which intern resulted in malnutrition of a large number of worms and therefore effected the productivity of cocoons. The rearers were advised to apply mulberry leaf twigs in different tiers one above other in a uniform way so that all the larvae could gain access to this leaf and feed properly. They also maintained recommended temperature of 26⁰-24⁰C & RH of 70-85% during rearing. Cleaning of rearing beds was done as per schedule with the help of ropes. Utilization of various bed disinfectants like RKO, Vijetha and lime were ensured after every moult. These systematic approaches resulted in success of silkworm rearing and increase in cocoon crop for the rearers.

3) **REARING HOUSES:-**

In Kashmir valley, silkworm rearing is performed only once in a year in the months of May-June. At present around 30300 rearers are associated with sericulture industry and a good number of rearers are willing to take up Sericulture/rearing of silkworms on a large scale. These are not in a position to practice it because most of the farmers in our state are poor having small holdings, living in very small dwellings or are even landless. Since silkworm rearing is an indoor activity and requires about 600-1000 sqft space for rearing one ounce (100 Dfl's) of silkworm seed, farmers are not in a position to rear silkworms due to dearth of space. In Kashmir, among other factors, lack of proper rearing space is also responsible for low cocoon crop in the region. The farmers having less accommodation either do not agree to take up silkworm rearing or if they do, they rear the worms in human and animal dwellings. As a result the crop yield gets drastically affected due to unsuitable accommodation and rearing conditions.. Keeping this in view, TSRI, Mirgund took an initiative to address the problem of inadequate rearing accommodation of farmers by way of fabricating low cost rearing huts near the farmers dwellings. These huts were constructed at different locations from the locally available material involving very meagre and affordable investment. The huts were constructed at different places viz: 1. Mirgund, 2.Chainabal 3.Chainable- 2, and 4.TSRI,Mirgund, SKUAST-K where silkworm rearing was done successfully inside these huts by the rearers. The size of each hut is 15' x 12' having three tiers internally. Externally it is fitted with a door of 0.9m x 1.8m (3' x 6') made of popular wood shutter with traditional latches. The floor of the hut is smoothly plastered with mud and straw paste (kachcha floor). The skeleton of roof is made of medium sized logs of

willow and popular trees covered with locally available paddy grass, typha grass etc so that optimum hygro-thermic conditions could easily be maintained. For proper air circulation, the side walls of huts is covered with gunny cloth over which cover of poly sheets is spread so that the temperature is raised to the optimum level and could be easily rolled and lifted up to lower down the temperature as and when required. Since it is not possible for the poor rearers to install thermostatically controlled air-heating or air-cooling devices, therefore, the easy way to maintain temperature and humidity inside the huts is done by burning small sigries (fire pots) inside the hut and by hanging wet gunny cloth on the doors of the hut.

4) MOUNTING AND MOUNTAGES:-

The larva after maturation spins a silken amour around its body in the form of a cocoon for protection during metamorphosis. This cocoon is exploited for commercial purposes. The required temperature of 23⁰-25⁰C and RH of 60-65% is to be maintained by all the rearers during seriposition. In addition to that semi dark conditions are to be maintained during seriposition. For spinning a cocoon the larvae needs a support which is provided in the form of a mountage or mounting material. Various types of mountages have been identified in different sericulture practicing countries. These include Rotary mountages in Japan, Plastic bottle brush mountages in Brazil, Bamboo frames in China and Chandrika in India. In addition to these many other mountages have been evaluated by the scientists world over. In Kashmir valley silkworm rearers mostly use various locally available mounting materials for seriposition . These include:

- Mustard hay (*Brassica campestris* L.), Paddy straw (*Oryza sativa* L.)
- Rapeseed hay (*Brassica campestris* L.) Hackberry (*Celtis australis* L.)
- Flex weed (*Descurina sophia*) Goose-foot (*Chenopodium scoparia*),
- Indigofera (*Indigofera haterantha*) and Pine shootlets (*Pinus excels* Wall).
- These mounting material have certain disadvantage as these are not available with each & every silkworm rearer at the time of seripostion. The shape & size of cocoons is not properly maintained in these mounting materials. If used without drying properly these are prone for fungal attack which damages cocoons. Mortality of larvae is more in these mounting materials due to poor aereation during seriposition. Dead & unspun worms can't be removed easily which cause staining of cocoons at

the time of harvest. Some of the newly introduced mountages are:-

ROTARY MOUNTAGE

It is made up of pieces of cardboard assembled in a checkerboard pattern. The mountage frame has 156 sections (13×12). Each section is 3 cm deep which is used by silkworm to spin cocoon. 10 such card board frames are attached with a wooden frame. 1560 worms can be mounted for seriposition, but only about 75- 80%

i.e 1200 worms are mounted on each mountage. After mounting worms for seriposition these mountages are hung up with ceiling. Minimum number of double, urinated and stained cocoon are formed in this mountage. The reelability also improves in the cocoons formed in this type of mountage due to aeration.

Harvesting of cocoons is done by a wooden harvester locally made by using wood. As this mountage has to be hanged with ceiling as such it becomes difficult for the poor rearers as they have dwelling houses where there is not such facility where these can be hanged with ceiling. As such these were redesigned so that these could be mounted on a frame which could be put on the floor for self mounting. Some new mountages have been designed in this way which are as under:-

MOUNTING-FRAME MOUNTAGE

(Card board frames mounted on Iron or wooden frames)

It consists of two Iron or wooden frames of 120×80 cms each connected with each other with two hinges. It is used for self mounting on the floor or shelves for mounting mature larvae by picking method. It is kept on the floor in “A” shape without hanging with ceiling. Four card board frames of rotary mountage can be fixed on this frame for seriposition of silkworms. Eight such card board frames can be fixed on each mounting-frame at a time. It has a capacity of mounting about 1248 worms. However only 75-80% i.e 1000 worms are mounted on each such mountage for seriposition. Harvesting is done with same harvester which is used in rotary mountages.

PLASTIC-FRAME MOUNTAGE

(Plastic collapsible mountage fitted on wooden frame)

It consists of two wooden frames of $180 \times 180 \times 5$ cm (L×B×D) each connected on one side with each other with hinges. The frames are kept on the floor so that way that it makes “A” shape. Four collapsible plastic mountages can be fitted on each frame on both sides for seriposition of cocoons. Picking method used for mounting. Full aeration is maintained.

Mortality of worms and formation of double cocoons is reduced. It has a capacity of mounting about 1000 worms. However only 75-80% i.e about 800 worms are mounted on each such mountage for seriposition. These plastic collapsible mountages are separated from the frames and subsequently cocoons are harvested manually.

5) HARVESTING OF COCOONS :-

The rearers usually harvest cocoons earlier than the actual recommended time of 6 or 7 days after seriposition. Due to this early harvest they used to get more melted and stained cocoons in their crop. Fresh air should be allowed continuously inside the mounting rooms so that aeration is maintained during cocoon formation. The rearers should maintain recommended temperature of 23-25⁰ C and RH 60-65% during spinning. Dead and non-spinning larvae should be picked up on 4th day after mounting by using fork and small container. By doing so decaying of larvae and staining of cocoons is minimized to a large extent. Harvesting of cocoons should be done on 7th day of mounting as against early harvesting and good and defective cocoons should be put in separate baskets, which prevented staining of good cocoons and as such fetched remunerative price to rearers for their cocoons.

6) DRYING OF COCOONS :-

Usually farmers dry their cocoons directly under sunlight, which deteriorates the quality of cocoons and thereby reduces their price in the market. In order to maintain the quality of cocoons drying of cocoons was done under black cloth till they got fully dried. This helped in long storage of cocoons and also fetched good price in the cocoon market.

LOW COST SOLAR COCOON DRYER

These low cost solar cocoon dryers are used for drying the cocoons. These are of two types

- One consists of a rectangular iron frame whose base is made up of a perforated tin sheet and the size of this rectangular tray is 3 × 4 feet. A mirror is mounted on the back of this tray which is adjusted to reflect solar light on the cocoons. This cocoon dryer is a multipurpose dryer and can be used for drying of various vegetables etc in off seasons after drying cocoons by the farmers. Approximate cost of this dryer is Rs 2500/- only. The other one which has eight dryers can be used by big farmers. This has a mirror on the top which can be kept at different angles so that solar energy is used for drying the cocoons spread inside these wire mesh dryers. Initially green cocoons are spread in thin layers (not more than two cocoons thick) on the tray of this dryer. After this dryer is kept at an angle of 20-25⁰ C

facing sun in order to utilize maximum solar energy by using mirror reflector. The trays are covered with black cotton cloth as the heat energy in sun light is absorbed by the black cotton cloth and radiated to green cocoons beneath at a higher temperature. These cocoons along with black cloth are covered by plain glass sheet in order to maintain higher temperature inside. A temperature of 70-80⁰ C is recorded inside the dryer when ambient temperature is only 30-33⁰ C. Higher temperature dries cocoons within 3.5 to 4 days as against 6-7 days (temp. 30-33⁰ C) . The perforations / mesh present on the floor of dryer allows air movement under the trays and facilitate removal of moisture from cocoons.

ADVANTAGES

- Cocoons dry faster than direct sunlight.
- Silk recovery and reelability are higher.
- Wastage of silk is less and original colour is maintained.
- Economical, maintenance free and quality of cocoons maintained by avoiding exposure of cocoons to ultra violet rays.

PRECAUTIONS

- Use jet black poplin cotton cloth only.
- Cloth surface should be in contact with the cocoon layers beneath.
- Put plain glass sheet over the black cloth so that it remains airtight.
- Allow movement of air under the trays to remove moisture. Moisture build up would lead to improper drying and even moth emergence.
- Shuffle cocoons present in the tray 2-3 times in a day for uniform drying.
- Continue to dry the cocoons till the dry cocoon weight is around 45-50% of green cocoon weight.

7) STORAGE OF COCOONS :-

In Kashmir valley marketing of dry cocoon starts from the month of August, as such rearer's should store these cocoons properly in such a way that pests and rodents do not cause any damage to these till their marketing takes place. The rearers should store their cocoons in loose gunny cloth / cotton cloth bags and hang them from the ceiling of rooms with the help of ropes. By doing so cocoons will be saved from any pest and rodent damage and get good price in the market.

CHAPTER 7: MULBERRY PESTS AND THEIR MANAGEMENT

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INTRODUCTION

Mulberry plantation a stable agro-ecosystem and till date no major problem was encountered in mulberry farming though many pests do occur associated in the system. Changing climatic conditions, global warming and frequent exchange of related plant material can at occasions be matter of concern and cause havoc with the sericulture industry.

Mulberry trees are important for silkworm (*Bombyx Mori L*) feeding do inhabit many pests like *Glyphodes pyloalis*, the Lesser mulberry snout moth, Lesser mulberry pyralid or Beautiful Glyphodes Moth, is a moth in the Lepidoptera, Pyralidae family . *Glyphodes pyloalis* Walker, is a monophagous pest of mulberry The mean total developmental period from egg to adult was 35 days. The maximum adult longevity was 7 and 11 days for males and females, respectively. Life expectancy of freshly laid egg was 32.15 days. It is a serious pest under Kashmir conditions, though it is well under economic threshold level. Intensive care is required for keeping the pest well under control. The pest can cause defoliation beyond proportions it also is responsible for spread of diseases of mulberry insect as it is a potential vector. Larvae of the pest form fine thread on the abaxial side of the mulberry leaves and eat the mesophyll form under those threads leaving a network of epidermis (Aruga, 1994). In addition *Glyphodes pyloalis* larvae are alternate hosts of *Bombyx* densoviruses and picornaviruses (Watanabe et al 1988).

MANAGEMENT:

- Keep the mulberry orchard hygienically clean.
- Tree stand should be grown in such a way so that the sunlight crosses through.
- Mulberry Pyralid should be taken seriously during the young leaf stage. The plantation should be thoroughly and seriously scouted to encounter the presence of the pest.
- Initially when the infestation is less, pluck the infested leaves carefully and collect them properly for final burial.
- In case the application of an insecticide is unavoidable proper care should be taken before the silk moth is fed. Even post-spray period that is waiting period of the insecticide given should be taken into the account.



There are many other insects associated with the Mulberry but they all are just at occurrence level only. Those pests which cause harm to the mulberry plantation are Chafer beetles, stem and root borers, slugs and snails, rodents. At latter stages when the tree gains age are attacked by stem borers and root borers. For lesser rodent and mollusk population keep the orchard clean, avoid weeds, other vegetation on bunds and ridges. Also do not allow orchard refuse deposit and plant litter and unrotten material.

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CHAPTER 8: DISINFECTION - A PREREQUISITE FOR SUCCESSFUL COCOON CROP

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Silkworm *Bombyx mori* L. has been domesticated since centuries for production of silk, which has made it highly sensitive to environmental conditions. Often there are cocoon crop losses due to various diseases. Pathogens responsible for the outbreak of diseases are well acclimatized to the conditions of temperature and humidity required for rearing of silkworms. As such the only effective way for controlling the disease occurrence is elimination of the pathogen from the rearing environment which can be achieved through proper disinfection and maintenance of rearing hygiene.

Silkworms are highly susceptible to diseases caused by various bacteria, fungi, viruses and microsporidia and once there is outbreak of disease it becomes difficult to control these. In fact diseases are one of the major constraints in successful sericulture. In India the cocoon crop loss due to silkworm diseases is about 30-40% (Santha *et al.*, 2007) and in Jammu and Kashmir loss due to nuclear polyhedrosis only has been reported to be 13.8- 26.0 % (Illahi, I. and Nataraju, B. 2007).

Occurrence of diseases particularly Viral is mainly due to the un hygienic rearing conditions. Improper disinfection of rearing houses and equipment also results in disease incidence (Munshi *et al.*, 1999). There are no curative methods for any of the silkworm diseases and they are best prevented than cured. This is achieved by adoption of proper and effective method of disinfection and step- wise maintenance of hygiene during the rearing. This helps to a considerable extent in bringing down the menace of pest and diseases. (Govindan *et al.*, 1998).

DISINFECTION.

Disinfection means extermination and destruction of disease causing pathogens. Disinfection is also conducted as a prophylactic measure to prevent silkworms from disease infections and to ensure successful cocoon crop. Disinfection can be conducted by both physical and chemical methods.

A. Physical methods:-

Physical methods include burning /burying of diseased /dead worms and by subjecting equipment to sunshine. Sun shine has strong disinfecting power against pathogens in view of UV rays. Kenchu Virus losses its infectivity when contaminated trays are exposed to hot sun.

B. Chemical methods:-

Chemical disinfection methods involve disinfection either by spraying or fumigation. The efficacy of chemical disinfectant is influenced by temperature, moisture, concentration of disinfectant and duration of treatment.

Characteristics of disinfectant:- An ideal disinfectant is the one which is:-

- i. 100% effective against all pathogens and is not specific.
- ii. Effective at all temperatures.
- iii. Cheaply and easily available and does not create health hazard to human beings and domestic animals.
- iv. Fairly stable and homogenous.

Various disinfectants used in Sericulture are formalin, Bleaching powder; iodine compounds ; Calcium hydroxide; Chlorine dioxide (Venketa reddy *et al.*, 1990; Subba Rao *et al.*, 1992 and Balavenketasubbaiah, *et al.*, 1993). Xiaotelin has also been advocated as an effective disinfectant against pathogens of silkworm (G.P.Singh *et al.*, 2002). The most commonly used disinfectants are formalin, bleaching powder and chlorine dioxide.

Formalin:- Formalin is 36 percent aqueous solution of formaldehyde. Its specific gravity is 1.087 and has irritating odour. It acts as a strong reducing agent, de-oxidises the pathogens and kills them. It is effective under controlled conditions of temperature and relative humidity and is suitable for closed type of rearing houses. It can also be used as fumigant. Due to its irritating nature it is not suitable for rearing cum dwelling houses. It is effective at 2% concentration.

Bleaching powder:- It is white amorphous powder with pungent smell of chlorine. For effective disinfection it must have 30 percent active chlorine content. Being hygroscopic it should be stored in sealed bags. It has strong oxidizing power against pathogens, Ca ion is also germicidal while as Cl_2 acts on the cell membrane and changes permeability of membrane, diffusion takes place and spore breaks after 10-15 minutes (pebrine spore). It is effective against all pathogens and is not temperature dependent. Although corrosive, bleaching powder is not a health hazard to human beings and domestic animals. It is used at 2% concentration with 0.3% slacked lime.

Chlorine dioxide:- It is an ideal disinfectant (generally available as Sanitech) having advantages over formalin and bleaching powder. It is stable and can be activated at the time of use by adding activator into the main disinfectant, usually available in 500 ml bottles to which 50 gms of activator are added for activation. It is comparatively lesser corrosive than bleaching powder. It is used at 2.5% concentration along with 0.5% slacked lime.

Lime :- it is available as white amorphous powder. The slaked lime by its alkaline activity destroys the silkworm viruses. It is even effective against polyhedra of nuclear polyhedrosis virus.

Preparation of disinfectant solution:- 2% formalin solution is prepared by mixing one part of 36 percent commercial formalin with 17 parts of water. For preparation of 2% bleaching powder in 0.3% of slaked lime, firstly 20 gms of bleaching powder are mixed in a small volume of 0.3% slaked lime solution to make a paste then it is diluted to one liter. For preparation of 0.3% slaked lime 3 gms of slaked lime are added to one liter of water. For preparation of 1 liter of Sanitech in 0.5 % slaked lime solution, the requirement is 25 ml of Sanitech +2.5 g of activator crystals +5 g of slaked lime.

To one bottle of 500 ml 50 g of activator are added (solution A), 100 g of slaked lime are added to little quantity of water to make it pasty and to this further water is added to make it 19.5 liters (solution B) Then solution A & B are mixed to get 20 lts of 2.5 percent chlorine dioxide in 0.5 % slaked lime.

Quantity of disinfection:- Quantity of disinfection required is same for formalin, bleaching powder and chlorine dioxide. It is calculated @ 2.5 lts /sq mt floor area and @ 400 ml/sq mt surface area. For mud floor area it is calculated @200 gm/sq mt floor area.

Spraying of disinfectants :- All these disinfectants are to be sprayed by using hand operated or motor driven sprayers well before the commencement of the rearing. Before disinfection the rearing rooms and appliances are thoroughly cleaned. While going for formalin as disinfectant the rooms are made air tight and temperature of 20 - 25°C is maintained.

BED DISINFECTANTS

Bed disinfectants are the chemicals which are used with the sole aim of controlling/ preventing the disease occurrence. The common bed disinfectants used in sericulture are; Captan, Dithane M45, Resham Keet Oushad (RKO) and Vijetha (Baig *et al.*, 1990; Baig *et al.*, 1993; Balavenkatasubbaiah *et al.*, 1994; Tanz-d *et al.*, 1995; Datta *et al.*, 1998 and Nataraju *et al.*, 1999).

Captan and Dithane M45 are contact fungicides and act by inhibiting the oxidative enzymes of pathogens which result in death of pathogen. These are mixed thoroughly with the inert material like Rangoli powder or Kaolin. These fungicides are used at 1 % concentration for young age worms and at 2% concentration for late age worms. RKO is a para formaldehyde based formulation and is used as such, it is effective against Muscardine and Grasserie. Vijetha is effective against all the pathogens of silkworm.

Application:- All these bed disinfectants are dusted on the larvae out of each moult and on the 4th day of 5th instar @3 g for chawki worms and 5 g for late age worms. The larvae are fed after 30 minutes of application. Usually 3 kgs of dusting mixture are required for 100 dfls under rearing. These bed disinfectants should not be dusted on the worms under moult. When dusting of bed disinfectant is to be done on 4th day of 5th instar it should be done after thorough bed cleaning.

HYGIENE DURING REARING.

Maintenance of hygiene during the rearing and practicing simple measures help to a greater extent in preventing the access of the pathogens from outside to the rearing venue and also their spread in the rearing bed or room.

Personnel hygiene during the rearing.

To ensure personnel hygiene wash hands with 1 % bleaching powder in 0.3 % slaked lime solution and walk over the foot mat containing 5 % bleaching powder in slaked lime.

Hygiene during cleaning.

For ensuring proper hygiene during rearing following steps should be taken:-

- Before starting cleaning, rearing bed should be screened for the diseased and dead larvae, which should be kept in a pot containing 5 % bleaching powder solution in slaked lime.
- Clean the rearing bed by using cleaning nets.
- Litter be collected in separate basket or on vinyl sheet and dumped into the litter pit away from the rearing house or mulberry garden, process it for making compost.
- Infected larvae be burnt or buried in soil.

Rearing hygiene:-

For ensuring proper hygiene during rearing following steps should be followed:-

- Rear silkworms on a sheet of paper which needs to be changed at the beginning of each instar.
- Avoid over feeding as it leads to increase in bed refuse and unhygienic conditions in the rearing bed.
- Provide optimum temperature, humidity and ventilation.
- Make use of bed disinfectants.
- Avoid borrowing of rearing equipment.
- Chawki and late age rearing be done in separate rooms.
- Entry to the rearing room should be restricted to few members.
- Do not store mulberry leaves inside the rearing rooms, store in separate disinfected rooms.
- Use separate baskets for collection of mulberry and for feeding of worms.

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CHAPTER 9: EXTENSION STRATEGIES/TEACHING METHODS FOR PROMOTION OF SERICULTURE

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Technology means application of science to the practical aim of human life. It refers to the transformation of scientific laws into machines, tools, mechanical devices, instruments, innovations, procedure and techniques to attain tangible ends or manipulate environment for practical purposes. Technologies refers to both hardware e.g. machines, equipment's and software such as programme or procedure of working or running machines.

Agricultural technologies refers to various techniques of crop production, crop improvement, crop protection, crop processing etc. e.g. multiple cropping, insects, tractors, integrated pest management. Agricultural technology is a complex blend of materials, processes and knowledge

Transfer of Technology:

Transfer of technology refers to the entire process of technology development, processing, dissemination and integration through research, extension and farming systems. It is a collaborative effort between the three partners. Each of the three functions of technology development, processing and dissemination has to be done in consultation with each other.

- Transfer of Technology refers to the activities of research systems (State Agricultural Universities, Indian Council of Agricultural Research, Agricultural College, Private research organisations, etc.
- In order to be accepted and integrated into social systems technologies must be developed keeping in view farmers existing practices, resources, environment and preferences.
- Technologies must provide solution to farmers problems.
- Communication of technologies alone is not enough. The other aspect viz. infrastructure, support services policy, marketing, input, training etc. must be assured for effective utilization.

Agricultural Extension Methodologies are aimed at improving agricultural productivity levels and farmers income. They include amongst others, training to transfer technical knowledge about new production technologies and provision of information on newly issued government policies. Other examples are the creation of demonstration models, the organization of study visits, and setting up of farmer's interest groups. In the field of agriculture and rural development, the methodologies are designed to achieve the four main purposes.

- To provide outsiders timely, cost effective, relevant, physical and social information concerning magnitude, spatial and time patterns, flow, trends and relationships with

respect to specified problems, and insight into concrete local opportunities for development intervention.

- To strengthen the self management and self development capacities of community and individual themselves.
- To develop shared understanding of sustainable resource systems and their management over scales larger than the farm unit and longer than a year or crop season.
- To bring about consensus for action among disparate, potentially confrontational actors, in conditions of uncertainty, about complex decisions which cannot wait upon the results for longer term research.

EXTENSION TEACHING METHODS:

A method is a procedure or process for attaining an objective. The choice of a channel or method of communication, also known as extension teaching method, generally depends on the number and location of target audience and the time available for communication.

An extension teaching method may, be defined as a sequence of progressive steps, undertaken to create situations that are conducive to effective learning.

According to Leagans (1961), extension teaching methods are the devices used to create situations in which communication can take place between an instructor and that learner.

As Ensminger (1957) said, before an extension worker can become efficient in the use of methods, he must know what methods are available, when to use a given method, and become effective in using each.

FUNCTIONS:

The following are the functions of extension teaching methods :

- (1) To provide communication so that the learner may see, hear and do the things to be learnt.
- (2) To provide stimulation that causes the desired mental and or physical action on the part of the learner.
- (3) To take the learner through one or more steps of teaching-learning process, viz. attention, interest, desire, conviction, action and satisfaction

CLASSIFICATION OF EXTENSION TEACHING METHODS:

Wilson and Gallup (1955) classified extension teaching methods according to their use and form. Bains (1987) attempted to classify them according to their use, form, stages of learning process, stages of adoption process, categories of adopters, initial cost involved, cost per unit of results obtained, skill required in using them, time consumed in using them and according to behavioural changes intended. However, most of these classifications are only of academic interest. The most widely used as well as useful classification of extension teaching methods is according to use.

Classification of extension teaching methods according to use

Individual Contact	Group Contact	Mass Contact
<ul style="list-style-type: none"> • Farm and home visits • Farmer's call • Personal letter • Telephone call • Adaptive trial 	<ul style="list-style-type: none"> • Result demonstration • Method demonstration • Group meeting • Small group training • Field day • Study tour 	<ul style="list-style-type: none"> • Farm publications • Mass meeting • Campaign • Exhibition • Newspaper • Radio • Television • Posters

Another classification of extension teaching methods which is very common in extension publications is according to their form

Classification of extension teaching methods according to form

Written	Spoken	Visual	Spoken and Visual
<ul style="list-style-type: none"> • Bulletins • Leaflets • Personal letters • Circular letters • Farm journals 	<ul style="list-style-type: none"> • Meetings • Farm and home visit • Office calls • Radio and recordings • Telephone calls 	<ul style="list-style-type: none"> • Result demonstrations • Exhibits • Posters • Charts • Slides • Film strips • Flash cards • Flannel graphs • Bulletin boards 	<ul style="list-style-type: none"> • Method demonstration • Result demonstrations • Television • Movies • Puppets • Campaign

Individual Contact Method:

Extension methods under this category provide opportunities for face-to-face or person-to-person contact between the rural people & the extension workers. These methods are very effective in teaching new skills & creating goodwill between farmers & the extension workers.

Advantages of the individual method are:

- It helps the extension agent in building rapport.
- It facilitates gaining firsthand knowledge of farm and home.

- c. It helps in selecting administrators and local leaders.
- d. It helps in changing an attitude of the people.
- e. It helps in teaching complex practices, and
- f. It facilitates transfer of technology effectively.

The limitations of the individual method are:

- a. This method is time consuming and relatively expensive.
- b. Has low coverage of audience
- c. Extension agent may develop favouritism or bias towards some persons

FARM AND HOME VISIT

Farm and home visit is a direct, face-to-face contact by the extension agent with the farmer or homemaker at their farm or home for extension work.

Objectives

- To get acquainted with and gain confidence of farmers and homemakers.
- To obtain and/or give firsthand information on matters relating to farm and home.
- To advice and assist in solving specific problems and teach skills.
- To sustain interest.

Technique

Planning and preparation

- Decide on the audience and the objective- whom to meet and what for?
- Get adequate information about topic. Contact research if needed.
- Collect relevant publications and materials to be handed over.
- Make a schedule of visits to save time and energy.
- If possible, send advance information.

Implementation

- Visit on scheduled date and time or according to convenience of the farmer and the person is likely to listen.
- Create interest of the farmer and allow the individual to talk first.
- Present the message or point of view and explain up to the satisfaction of the farmer.
- Answer to questions raised and clarify doubts. Hand over publications.

- Try to get some assurance for action.

Follow-up

- Keep appropriate record of visit.
- Send committed information or material.
- Make subsequent visits as and when necessary.

Advantages

- Provides extension worker with firsthand knowledge
- Builds confidence
- It helps to identify local leaders
- Develops good public relations

Limitations

- Only limited number of contacts may be made
- Time consuming and costly method
- Attention may be concentrated on a few big and progressive farmers; neglecting the large number of small, marginal, tribal farmers, landless labour and backward people; which may prejudice them

Farmers Call

Farmer's call is a call made by a farmer or homemaker at the working place of the extension agent for obtaining information and assistance.

Objectives

1. To get quick solution of problems relating to farm and home
2. To enable the farmer and homemaker to bring specimens for proper identification of the problem
3. To ensure timely supply of inputs and services
4. To act as a reminder to the extension agent

Technique

Planning and preparation

- Keep the office neat, orderly and attractive
- Remain present in the office on a fixed days and hours, which have been communicated to the farmers and homemakers in advance
- Make alternative arrangements to provide information and assistance to the caller in case of absence.

Implementation

- Allow the visitor to talk first and make the point
- Discuss about his/her problems and suggest solutions. If necessary take the person to the subject matter specialist
- Let the visitor leave the office satisfied

Follow-up

- Make a note of the call, if necessary
- If required, refer the problem to research for solution
- Supply further information and materials if such commitment has been made
-

GROUP CONTACT METHOD

Under this category, the rural people or farmers are contacted in a group which usually consists of 20 to 25 persons. These groups are usually formed around a common interest. These methods also involve a face-to-face contact with the people & provide an opportunity for the exchange of ideas, for discussions on problems & technical recommendations & finally for deciding the future course of action.

Advantages

- It enables, extension agent to have face to face contact with a number of people at a time.
- It can reach a select part of the target group.
- It facilitates sharing of knowledge and experience and thereby strengthen learning of the group members.
- It satisfies the basic urge of people for social contacts.
- It motivates people to accept a change due to group influence.
- It is less expensive than individual method due to more coverage.

Limitations

- Wide diversity in the interest of the group members may create a difficult learning situation.
- Holding the meeting may be regarded as an objective in itself and
- Vested interests, caste groups and village fractions may hinder free interaction and decision making by the group members.

METHOD DEMONSTRATION

A Method Demonstration is given before a group of people to show how to carry out an entirely new practice or an old practice in a better way. It is essentially a skill training, where the emphasis is on effectively carrying out a job, which shall improve upon the result. It involves seeing, hearing, participating and practicing in a group which shall stimulate interest and action. Method demonstration is sometimes used as complementary to result demonstration.

Objectives

- To teach skill and stimulate to action.
- To get rid of inefficient or ineffective movements.
- To improve upon result by doing a job in a better way.
- To build up learners’ confidence and satisfaction on the practice.

Technique

Planning and preparation

- Decide on the topic, target audience and venue of demonstration.

- Select a topic which is important and needed by the group for immediate use.
- Contact subject matter specialists and ensure their participation.
- Collect relevant information, materials and equipment.
- Identify the steps in conducting the demonstration. Practice the demonstration, to be sure about its correct presentation.
- Decide on the date and time in consultation with the local leaders and give timely intimation to all concerned.
- Complete all arrangements for the demonstration.
- Display diagrams, charts, graphs etc. at the demonstration site.

Implementation

- Start the demonstration on the scheduled date and time.
- Show each operation step-by-step, explaining clearly why and how it is being done.
- Ensure that all the participants have seen the demonstration and have understood it.
- Repeat difficult steps, if required.
- Invite and participants one by one in small batches to practice the skill. Clarify doubts and answer to their questions.
- When everybody has practiced the skill and has expressed confidence, emphasize on the key points again.
- Hand over the relevant publications.

Follow-up

- Keep a record of the participants and maintain contact with them.
- Assist the participants in getting the required materials and equipment.

Advantages

- Suited to teach skill
- Seeing, hearing, doing and discussion stimulate interest and action
- Costly ‘trial and error’ procedure is eliminated
- Builds confidence
- Introduces changes at low cost
- Provides publicity

Limitations

- Suitable mainly for practices involving skills
- Needs good deal of preparation, equipment and skill of the extension agent

RESULT DEMONSTRATION

Result demonstration is a method of motivating the people for adoption of a new practice by showing its distinctly superior result. The demonstrations are conducted in the farm or home of selected individuals and are utilized to educate and motivate group of people in their neighbourhood. This is a very effective method for the transfer of technology in a community.

Demonstration may stimulate farmers to try out innovations themselves, or may even replace a test of the innovation by the farmers. They can show the causes of problems and their possible solutions without complicated technical details. A great advantage of demonstration is seeing how an innovation works in practice.

Objectives

- To show the advantages and applicability of a newly recommended practice in farmer's own situation.
- To motivate groups of people in a community to adopt a new practice by showing its results.
- To build up confidence of the farmers and extension agents.
- To develop innovation leadership.

Technique

Planning and preparation

- Analyse farmers' situation and select relevant profitable practices, in consultation with research worker and farmers.
- Select a few responsible and cooperating farmers having adequate resources and facilities and having acceptance in the local community for conducting the demonstration. This, however, does not mean that big farmers are to be selected.
- Select representative locations for conducting the demonstrations where it will be easily visible to a large number of people in the community.
- Prepare a calendar of operations

Implementation

- Explain the objectives and steps to the demonstrating farmers.
- Organize materials and equipments necessary for conducting the demonstrations.
- Give adequate publicity about the demonstrations.
- Start the demonstration on the scheduled date and time, in front of those who may be present. Explain the objectives to those who are present.
- Arrange method demonstration where a new skill is involved.
- Put up suitable signboard for each demonstration in prominent places. The signboard should be colourful and visible from a distance. Local language should invariably be used on the signboard.
- Ensure that all critical operations are done in time and try to supervise them personally.
- Conduct field day around successful demonstrations.
- Take photograph. Help the demonstrating farmers to maintain records.
- Motivate as many farmers as possible to remain present at the time of final assessment of the result.
- Let the demonstrating farmers explain to the visitors as far as possible.
- Analyze and interpret the result, and compare them with the farmers’ existing practice.
- Emphasize applicability of the new practice in the farmers’ own situations.

Follow-up

- Use the result of demonstrations in future extension work and also pass on to the mass media for further dissemination.
- Utilise demonstrating farmers in farmers’ meetings and training programmes.
- Prepare visual aids, particularly photographs, coloured slides, charts etc. on the demonstrations for future extension programmes.
- Avoid conducting subsequent demonstrations with the same farmers.

Advantages

- Create confidence among extension worker and farmers about new recommendations
- Useful in introducing new practice
- Contribute in locating local leaders
- Provide teaching material

Limitations

- Need more time, energy and funds for extension work.
- Unsuccessful demonstrations may cause some setback to extension work.

FIELD TRIPS:

It is a method in which a group of interested farmers accompanied and guided by an extension worker, goes on tour to see and gain first hand knowledge of improved practices in their natural settings (whether on research farms, demonstration farms, institutions or farmer's fields).

Objectives

- To stimulate the interest, conviction and action in respect of a specific practice.
- It helps to recognise problems, develop interests and promote adoption.
- It demonstrates feasibility of related practices to the learners in an informal way.

Technique

Planning

- Planning of field trip starts with decision about choice of a particular place of visit. In order to involve people in the educational activity, a committee can be formed consisting of members from participants and officials sponsoring the trip.
- Decide exactly what the trip is supposed to achieve so that details can be planned.
- Decide the places (sites) and practices to be visited.
- Plan for people to explain relevant details and values. Information to concerned people and their readiness can be ensured through advance planning.
- Work out time schedule, routes of visit and people to be introduced.
- Arrange for transport and necessary permission from authorities to make the trip.
- It is better to send extension staff to the site in advance to make local arrangements for visits, stay and board (if needed).
- Participants should be given precise instruction about where and when to meet. Assign responsibilities to participants.

Implementation

- Emphasize on the purpose of the trip so that it is not taken as a leisure-pleasure activity.
- Provide information on the sites and topics of visit.
- Ask participants to assemble in a manner that everyone can hear, see and discuss conveniently without any obstruction.

Follow-up

- Get the reactions of the farmers.
- Discuss the results with research worker and farmers and explore the suitability or otherwise of the practice for the area.
- If required, repeat the trial for one or two years more.

- On the basis of the performance, take a decision to recommend the practice for general or not.

Limitations

- Being scattered, the trials may suffer from lack of adequate supervision of the extension agent.
- Satisfactory results depend on the clarity of objective and careful selection of the practice and the farmers.

MASS CONTACT METHOD

In this method the extension agent communicates with a vast and heterogeneous mass of people, without taking into consideration their individual or group identity. Normally group boundary gets obliterated. This method is valid when a large and widely dispersed audience is to be communicated within a short time. There may be a few communicators such as the extension agent and some subject matter specialists. The size of the audience may be a few 100s in mass meeting, few 1000s in campaign and a few lakhs in newspaper, radio and television. A few examples of mass methods are farm publications, mass meeting, campaign, exhibition, newspaper, radio and television.

Advantages

- a. It is suitable for creating general awareness among the people.
- b. It helps in transferring knowledge on farming and changing opinions.
- c. Large number of people are communicated within a short span of time.
- d. Facilitates quick communication in times of emergency.
- e. Less extensive due to more coverage.

Limitations

- a. It is less intensive method.
- b. Little scope for personal contact with the audience.
- c. Generalized recommendations hinder application by individuals.
- d. Little control over the responses of the audience and
- e. Difficulty in getting feedback information and evaluation of results.

CAMPAIGN

A Campaign is an intense educational activity for motivating and mobilizing a community to action, to solve a problem or satisfy a need urgently felt by it.

The duration of campaign may be for a single day on a theme like ‘water for life’ for a few weeks as in ‘rat control’ or ‘family planning’ for few months as in ‘Vanmohotsava’ (tree planting) and for few years as in ‘Grow More Food’ campaign. A campaign may be held by involving small number of people in a few villages, or by involving entire community or the

entire nation over the whole country. Campaign around a theme may be organized only once, or may be repeated year after year, till the goal is satisfactorily reached.

Objectives

- To create mass awareness about an important problem or felt need of the community and encourage them to solve it.
- To induce emotional participation of the community at the local level and create a favourable psychological climate for adoption of new practices.

Technique

Planning and preparation

- Identify with the local leaders an important problem or needs of the community.
- List out specialists, local leaders and other persons who could be involved in solving it.
- Decide with the local leaders about the time of holding the campaign and its duration.
- Arrange necessary inputs, services and transport.
- Prepare a written programme of the campaign.
- Give wide publicity and put up posters at strategic points throughout the area. Use mass media to warm up the community. Make use of personal appeal.

Implementation

- Carry out the campaign as per programme.
- Hold group meeting with the people and discuss about the origin and nature of the problem. Suggest practical and effective solution.
- Arrange method demonstration and training programme for the participants.
- Maintain supply of critical inputs and services.
- Keep close watch on the campaign and take corrective steps, if necessary.
- Arrange mass media coverage.
- Conclude the campaign in time.

Follow-up

- Contact participants and find out their reactions.
- Assess the extent of adoption of the practice.
- Publicize successful campaigns.
- Analyze deficiencies and failures.
- Give due recognition to the local leaders.

Advantages

- Especially suited to stimulate mass scale adoption of an improved practice in the shortest time possible.
- Facilitates exploitation of group psychology for introducing new practices.
- Successful campaign create conducive atmosphere for popularizing other methods.
- Builds up community confidence.

Limitations

- Applicable only for topics of community interest.
- Success depends on cooperation of the community and their leaders.
- Requires adequate preparation, concerted efforts and propaganda techniques, and uninterrupted supply of critical inputs.
- Less suitable for practices involving complicated techniques.

EXHIBITION

An exhibition is a systematic display of models, specimens, charts, photographs, posters, pictures, information etc. in a sequence around a theme to create awareness and interest in the community.

This method is suitable for reaching all types of people. Exhibitions may be held at the village, block, district, state, national and international levels. Exhibitions are used for wide range of topics, such as planning a model village, demonstrating improved practices, different feeding methods, showing high –producing animals, new technologies and the best product of village industries.

Objective

- To provide visual literacy.
- To acquaint people with better standards.
- To create interest in a wide range of people.
- To motivate people to adopt better practices.

Technique

Planning and preparation

- Form a steering committee with specialist, local leaders and administrators.
- Decide on the theme and organizations to be involved.
- Prepare a budget estimate and procure funds.
- Decide on the venue, time and duration.
- Prepare a written programme and communicate to all concerned in time.
- Get the site ready within the scheduled date

- Reserve a stall for display of exhibits to be brought by the farmers.
- Arrange a pandal for holding meeting, training and entertainment programme.
- Display posters at important places and publicize about the exhibition through mass media.
- Decorate the stalls simply and tastefully. Make adequate arrangement for lighting.
- Display the exhibits at eye-level.
- If possible, arrange action and live exhibits.
- Train up interpreters and allot specific duties.

Implementation

- Organize formal opening of the exhibition by a local leader or a prominent persons.
- Arrange smooth flow of visitors.
- Let the interpreters briefly explain the exhibits to the visitors so that the intended message is clearly communicated.
- Organize a panel of experts to be present nearby, so that the visitors who would like to know more or discuss some problems could get the desired information.
- Conduct meetings, training programmes etc. as per schedule during the day time and use the stage for entertainment during nights.
- Judge the stalls on the basis of their quality of display, ability to draw visitors and effectiveness in communicating message.
- Keep the exhibits and the premises clean. Replace exhibits as and when necessary.
- Conclude the exhibition as per the schedule.

Follow-up

- Meet some visitors personally and maintain a visitor's book for feedback information.
- Talk to local leaders and assess success of the exhibition.
- Ensure availability of critical inputs and facilities emphasized during the exhibition
- Look for changes in practice in the community in the future.

Advantages

- Eminently suited to teach illiterates
- Promotes public relations and goodwill towards extension
- It can be fit into festive occasions and serve recreational purposes
- Can be used to stimulate competitive spirit
- Can create market for certain products.

Limitations

- Requires lots of fund and preparation
- Cannot be held frequently

However, normally no extension worker has ability to use all methods with equal skill. Further, there is no one method that is best for all situations alike and hence calls for different method (s). It is also obvious that no one method can reach all the audience. Behavioural changes required on the part of the learners may also require several exposures with the same, different or a combination of methods. Research bears ample evidence to suggest that a combination of methods or media-mix is required for effective technology transfer.

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CHAPTER 10: MULBERRY AS NUTRITIVE FODDER FOR LIVESTOCK

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Any agricultural stuff used specifically to feed livestock is called fodder. Plant species whether leguminous or non-leguminous, cereal by products, crop residues or tree leaves are commonly used for feeding livestock. The feed and fodder stuffs used for livestock are classified into three categories viz., crop residues, green fodder and concentrates. Of these crop residues contribute almost 60 percent to the available feed resources. A major challenge facing the livestock sector is the shortage of feed and fodder resources. As per the estimates given by National Institute of Animal Nutrition and Physiology the gap between supply and demand of feed and fodder resources in respect of crop residues, green and concentrates amounts to 33%, 25% and 47% respectively. As demand for milk and milk products will grow to at least 210 million tonnes by 2022, a rise of 36% over five years, production of fodder must grow by 5.5% per annum (State of India's Livelihood). To boost milk yield, India would need to generate 1,764 million tonnes of fodder by 2022. But existing sources can only manage about 900 million tonnes of fodder—a shortage of 49%. The advisory issued by IGFR Jhansi recommends optimal use of land resources, increasing production through use of high yielding varieties, use of trees, shrubs and grasses for development of pastures, development of short duration dual purpose crops which can be used during floods or drought, adopting suitable cropping combinations, improving waste lands, silvi-pastoral plantation in degraded lands, creation of fodder banks and strengthening of extension activities to mitigate the shortage of feed and fodder resources.

The use of tree forages as components of diets is a widespread practice in many countries (Singh and Makkar, 2002). These feed resources have good nutritive value, and positively impact rumen function and microbial yield (Leng, 1997). The use of such forages is also the most practical method that can be adopted locally by small-scale farmers. Fodder trees and shrubs have gained great attention for improving livestock productivity in developing countries (Franzel *et al.*, 2014). Recognition of the potential of tree foliage to produce considerable amounts of high protein biomass has led to the development of animal farming systems that integrate the use of tree foliages with local bulky feed resources.

A natural association of mulberry and livestock occurs in regions where mulberry trees are grown. Fallen leaves in the autumn are consumed by domestic animals. Mulberry is primarily grown for sericulture. In hilly areas, where mulberry trees are abundant, their leaves are fed to animals. It can be grown either as a tree or a shrub and harvested several times a year. Due to their high digestibility values mulberry leaves can be used to supplement low quality forages (Jayal and Kehar (1962) and its incorporation in livestock ration reduces the cost of production

(Mejia 2002). It is a perennial source of fodder, grows anywhere so can be used to reclaim waste land. It regenerates itself naturally from seeds that are dispersed by birds and to a limited extent by human beings. It can be propagated artificially by seeds or cuttings. It grows rapidly in the early stages and reaches maturity at an early age. The plant is resistant to most of the pest and fungal diseases, grows well even without chemical fertilizer supplementation. The fodder so obtained is free of chemical residues which in turn can help in raising organic livestock products. The fodder can be fed either fresh or stored easily after drying, pelting or through ensiling. Mulberry leaves have an appreciable potential as a protein source in livestock feeding. Complementary association of Mulberry with clover for sheep and cattle grazing leads to N fixation by the clover and contributes high quality forage during the summer. The association produces more forage over a longer period than the individual crop.

Nutritive value of leaf

Leaf yield varies from 35-45 tonnes of fresh leaf/ha/year. The leaves contain nearly 70 percent moisture. The nutritive value of mulberry is one of the highest found in products of vegetable origin and is far superior to cereal crop residues and traditional forages (Benavides *et al.*, 1994). The mulberry leaves are rich in crude Protein (CP), ether extract (EE), nitrogen free extract (NFE) calcium and ascorbic acid, and low in crude fiber (CF). The foliage of the mulberry is highly digestible and of excellent crude protein (CP) content reaching levels of 20-24% on a dry matter basis (Vu et al 2011). The percentage of moisture, protein and carbohydrates is higher in temperate regions when compared to the tropics. Even Mulberry leaf stalks, left after feeding silkworms, can also be used for feeding cattle without any adverse effect on their health and performance (table 1).

Table 1: Nutritive value of Mulberry

S. No	CP%	EE%	CF%	NFE%	Ash%	Ca	P%	S%	K%	Fe ppm
Leaves	20-24	1.5-3.7	9-15	48-49	14-22	2.4-4.7	0.2-0.9	0.2	1.6-3.2	350-840
Leaf	11.5	2.7	34	76.5	9.3	1.6	0.2	-	-	-
Stalks										

Mulberry leaves are good source of essential amino acids, lysine (1.88%) and leucine (2.55%) particularly (Riyadh *et al.*, 2013). The leaves are rich in ascorbic acid, carotene, vitamin B1, folic acid and vitamin D, compared to soybeans, the main protein source for intensive poultry. Even essential fatty acids like oleic, linoleic and arachidonic acid are found in appreciable amounts in mulberry leaf.

Mulberry leaf as fodder for ruminants

Mulberry is 80-100% better than grasses and 40-50% better than legumes for small ruminants (Sanchez 2002). The use of tree forages as components of diets is a widespread practice in many countries (Singh and Makkar, 2002). These feed resources have good nutritive value, and positively impact rumen function and microbial yield (Leng, 1997). The potential of mulberry leaves as a fodder crop has been investigated through various in vitro studies. Mulberry

leaves may be used as supplementary protein and energy source for ruminants (Liu et al. 2001). Diet supplemented with mulberry leaves leads to increased body weight gain in growing lambs (Benavides 2002) and milk production in goats (Gonzalez and Milera 2000). Experiments with sheep and cattle have shown that the mulberry leaves are nutritious and can be profitably utilized as a supplement to poor quality roughage diets (Singh and Makkar 2002). The ration of nitrogen to sulphur (15:1) found in mulberry, is considered adequate for growth of microbial protein synthesis in rumen. In addition the leaves are free from tannins (Singh and Makkar 2002). Feeding trials have shown that up to 6 kg of leaves per day can be fed to milch cows without adversely affecting the health of animals or the yield and butter content of milk (Singh and Makkar 2002). Mulberry is an excellent feed for high yielding animals and can be offered fresh or dried in compound feeds, and appreciably enhances quality and quantity of milk (Boschini 2002). Apart from increasing the quality and quantity of milk supplementation of fodder with mulberry can help in prevention of some of the economically important diseases, owing to rich minerals content.

Mulberry in poultry feed

Mulberry leaves can also be used in poultry rations. Incorporation of shade-dried mulberry to the extent of 6 percent showed an increase in egg production with desirable yolk colour without any adverse effect on body weight and egg quality (Narayana and Setty, 1977). Owing to its high carotene content, can form a valuable source of vitamin A for the health of poultry birds and increase egg production. As per Chowdary *et al.*, (2009) incorporation of mulberry into poultry feed to the extent of 10% resulted in increase in body weight, feed conversion efficiency and reduced feed intake. Suggesting that the mulberry leaf powder supplementation at 10% would cut down the cost of poultry feed. Use of mulberry leaves in diets for broiler chicken up to 5% decreases total content of saturated fatty acids, cholesterol, increases proportion of polyunsaturated fatty acids and linolenic acid in breast meat of broilers without any adverse effects on broiler performance (Margareta *et al.*, 2015). Mulberry leaves included in poultry feed significantly reduce the levels of ammonium sulphate (responsible for odour) in manure. Integration of poultry rearing into mulberry gardens can be beneficial in terms of weeding, additional organic fertilizer, quantity of poultry products and cost (Machii 2000).

Mulberry in Rabbit Diet

The effect of supplementing mulberry leaves *ad libitum* to concentrate diets of Angora rabbits on wool production indicates that mulberry leaves can be advantageously incorporated in the diets of Angora rabbits for wool production and can mulberry leaves can be supplemented up to a level of 40 percent of the DM (Singh et al 1984). In rabbits, the reduction of concentrate offered daily from 110g to 17.5g with *ad libitum* fresh mulberry only reduced gains from 24 to 18g/d, but decreased to more than half the cost of the meat produced (Laray Lara et al., 1998).

Mulberry in fish feed

Incorporation of mulberry in fish feed has proved to be the better in terms of survival rate, feed conversion ratio and growth rate of fish than feeds prepared from groundnut oil cake (Bag et al., 2012). Use of mulberry feed significantly reduced incidence of open sores, tail and fin rot diseases. Over all the input cost is also reduced. Even Silk worm waste can be used for feeding of fish and poultry to achieve high productivity and sustainability through recycling of waste.

Keeping in view the nutritive value of mulberry and its positive impact on the overall performance of livestock and easy integration with livestock systems and pisciculture, it can be used in appreciable amounts to achieve sustainable productivity and at the same time lower the input costs.

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CHAPTER 11: AGROFORESTRY NEED OF HOUR AND METHODOLOGY FOR CALCULATION OF AMOUNT OF CO₂ SEQUESTERED BY DIFFERENT AGROFORESTRY TREE SPECIES ON YEARLY BASIS.

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Concept Of Agroforestry

Agroforestry is not something new, what is new is the science of Agroforestry, the art is old. It is a collective name for land use system involving trees combined with Crops and/or animals on the same unit of land. Further it

- Combines production of multiple outputs with protection of resource base.
- Places emphasis on the use of multiple indigenous trees and shrubs.,
- Is practically suitable for low input conditions and fragile environments.
- Involves the interplay of sociocultural values more than in most other land use systems and
- Is structurally and functionally more complex than monoculture.

Definition:

Agroforestry denotes a sustainable land and crop management system that strives to increase yields on a continuing basis, by combining the production of woody forestry crops (including fruit and other tree crops) with arable or field crops and/or animals simultaneously or sequentially on the same unit of land, and applying management practices that are compatible with the cultural practices of the local population (ICRAF 1982) Combination of woody perennial crops with agricultural crops and/or livestock in space or time on a single unit of land (Agroforestry: basics).

Benefits from Agroforestry

Environmental benefits

- Reduction of Pressure on Forests.

- More efficient recycling of nutrients by deep rooted trees.
- Reduction of Surface Run off, Nutrient Leaching and soil Erosion, through impeding effect of tree roots and stem on these processes.
- microclimatic improvement
- Improvement of soil structure

Economic Benefits

- Reduction in total crop failure.
- Increment in an maintenance of outputs food, fodder, Fertilizer, Timber etc.
- Increase in levels of farm income due to improved and Sustained Productivity.

Social Benefits

- Improvement in rural living standards, (Sustained Employment).
- Improvement in nutrition and Health due to increased quality and diversity of Food.
- Improvement of upland communities

Limitations Of Agroforestry

- Possible Competition of trees with food crops for space, nutrients, light, moisture which can reduce food crop yields.
- Damage to food crops during tree harves operations.
- Trees serve as hosts to insects and pests which are harmful for food crops.
- Rapid regeneration of trees which may displace food crops
- Requirement of more Labour for different operations
- Longer rotation period of trees

- Resistance by Farmers to displace food crops with trees, especially where land is scarce and the fact that agroforestry is more complex, less well understood and more difficult to apply, as compared to single crop farms.

HOW TO OVERCOME LIMITATIONS

- Skillful Management.
- Selection of deep rooted trees so that they will absorb moisture and nutrients from the deeper subsoil , while the food crops receive their share from the surface layers.
- Selection of Legume trees that have small or light crowns so that sufficient sunlight will reach the food crops for photosynthesis.
- Space the trees farther apart to reduce their competitive effects on the food crops.

Methods for calculation of amount of CO₂ sequestered in a tree per year.

Non destructive method

The rate of carbon sequestration depends on the growth characteristics of the tree species, the conditions for growth where the tree is planted, and the density of the tree's wood. It is greatest in the younger stages of tree growth, between 20 to 50 years. Further complicating the issue is the fact that far less research has been done on tropical tree species as compared to temperate tree species. Nevertheless, we can roughly estimate the amount of CO₂ sequestered in a given tree, and if we divide by the tree's age, get a yearly sequestration rate.

The process is as

- 1. Determine the total (green) weight of the tree.**
- 2. Determine the dry weight of the tree.**
- 3. Determine the weight of carbon in the tree.**
- 4. Determine the weight of carbon dioxide sequestered in the tree**
- 5. Determine the weight of CO₂ sequestered in the tree per year**

Determine the total (green) weight of the tree

Based on tree species in the Southeast United States, the algorithm to calculate the weight of a tree is: 3

W = Above-ground weight of the tree in pounds

D = Diameter of the trunk in inches

H = Height of the tree in feet

For trees with $D < 11$:

$$W = 0.25 D^2 H$$

For trees with $D \geq 11$:

$$W = 0.15 D^2 H$$

Depending on the species, the coefficient (e.g. 0.25) could change, and the variables D^2 and H could be raised to exponents just above or below 1. However, these two equations could be seen as an “average” of all the species’ equations. The root system weighs about 20% as much as the above-ground weight of the tree. Therefore, to determine the total green weight of the tree, multiply the above-ground weight of the tree by 120%.

Determine the dry weight of the tree

This is based on an extension publication from the University of Nebraska.⁴ This publication has a table with average weights for one cord of wood for different temperate tree species. Taking all species in the table into account, the average tree is 72.5% dry matter and 27.5% moisture. Therefore, to determine the dry weight of the tree, multiply the weight of the tree by 72.5%.

Determine the weight of carbon in the tree

The average carbon content is generally 50% of the tree’s total volume.⁵ Therefore, to determine the weight of carbon in the tree, multiply the dry weight of the tree by 50%.

Determine the weight of carbon dioxide sequestered in the tree

CO₂ is composed of one molecule of Carbon and 2 molecules of Oxygen.

The atomic weight of Carbon is 12.001115.

The atomic weight of Oxygen is 15.9994.

The weight of CO₂ is $C + 2 \times O = 43.999915$.

The ratio of CO₂ to C is $43.999915 / 12.001115 = 3.6663$.

Therefore, to determine the weight of carbon dioxide sequestered in the tree, multiply the weight of carbon in the tree by 3.6663.6

Determine the weight of CO₂ sequestered in the tree per year

Divide the weight of carbon dioxide sequestered in the tree by the age of the tree.

EXAMPLES

Estimated growth rates and sizes of agroforestry trees were taken from the World Agroforestry Centre’s “Agroforestry tree Database”⁷:

Let’s see how much a tree might sequester in a year. Let a 10-year-old tree grows up to 15 feet tall with a trunk about 8 inches in diameter. Therefore:

$$W = 0.25D^2H = 0.25(82)(15) = 240 \text{ lbs. green weight above ground.}$$

$$240 \text{ lbs.} * 120\% = 288 \text{ lbs. green weight (roots included)}$$

$$288 \text{ lbs.} * 72.5\% = 208.8 \text{ lbs. dry weight}$$

$$208.8 \text{ lbs.} * 50\% = 104.4 \text{ lbs. carbon}$$

$$104.4 \text{ lbs} * 3.6663 = 382.8 \text{ lbs. CO}_2 \text{ sequestered}$$

$$382.8 \text{ lbs} / 10 \text{ years} = \mathbf{38.3 \text{ lbs. CO}_2 \text{ sequestered per year}}$$

Or consider a 10-year-old *Grevillia robusta*, 45 feet tall with a trunk 6 inches in diameter Using the same calculations as above, the amount of CO₂ sequestered would be **64.6 lbs.**

per year. Or a newly-planted *Acacia angustissima*, 2.5 years old, 15 feet tall with a trunk 3 inches in diameter: **21.5 lbs.** of CO₂ sequestered per year. Or an *Albizzia lebbek*, 15 years old, 30 feet tall, with a 12 inch trunk: **68.9 lbs.** of CO₂ sequestered per year.

Other methods

Another way to estimate the amount of CO₂ sequestered by a tree in a year is to estimate the amount sequestered in a hectare per year, and divide that amount by the number of trees per hectare. Scanning around on the Internet, it seems that the number of trees per hectare (in agroforestry and/or industrial plantations) ranges from under 500 to over 2,000.

According to Myers and Goreau, tropical tree plantations of pine and eucalyptus can sequester an average of **10 tons** of carbon per hectare per year. ⁸ Therefore, the plantation can sequester an average of 20,000 lbs * 3.6663 = 73,326 lbs CO₂/ha/year, or, taking an average of 1,000 trees per hectare, **73.326 lbs CO₂/tree/year**.

Of course, we heavily discourage the planting of pine and/or eucalyptus in our agroforestry systems. Our trees may not grow as fast or as straight as eucalyptus, but they are not invasive, and they do not destroy the water table and the soil!

Disclaimer

This research and methodology is based on research papers, university publications, and other information freely available on the Internet. As stated before, it is difficult to calculate the amount of carbon dioxide sequestered per tree per year due to the complexity of the variables involved, as well as the lack of research on tropical tree species.

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