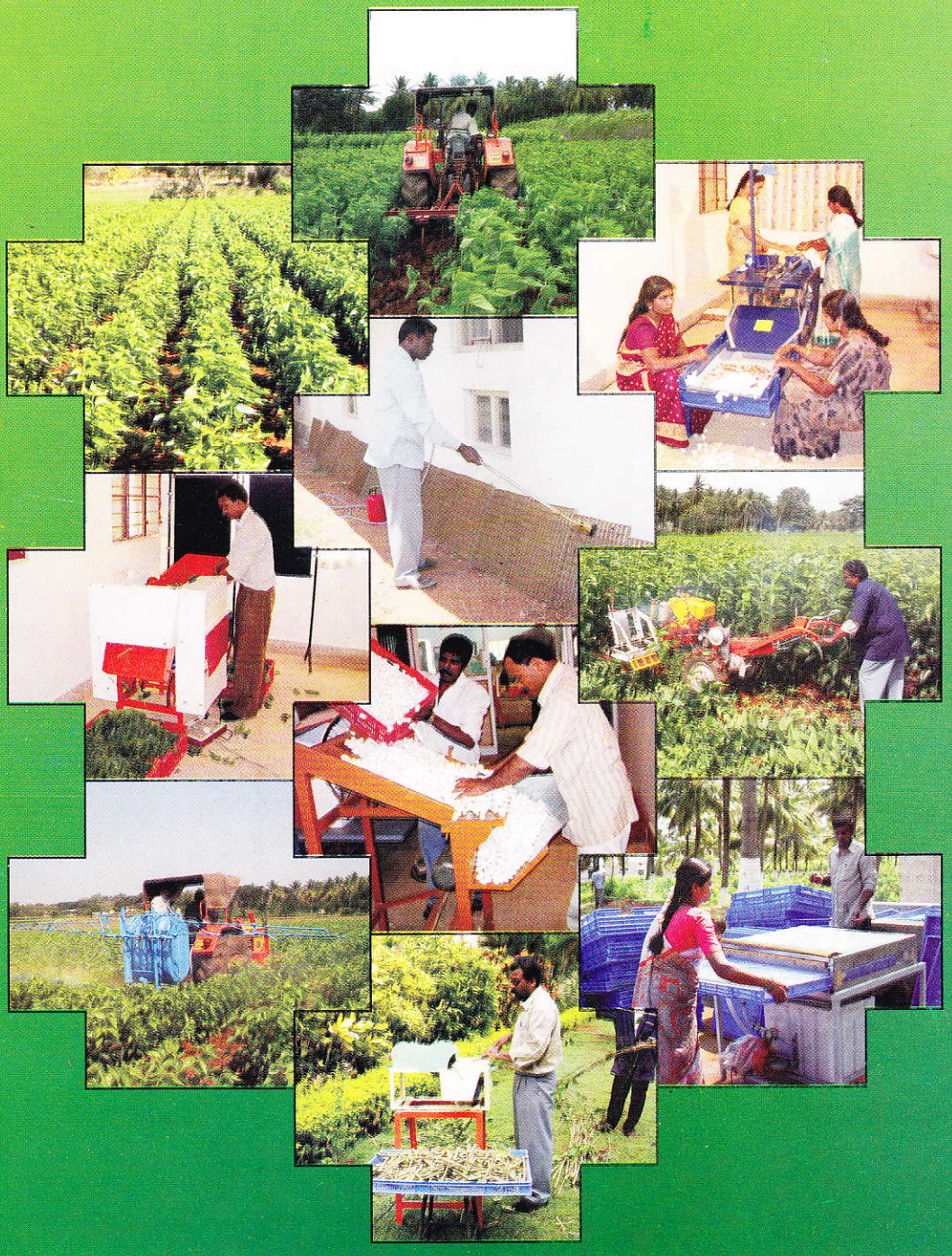
Mechanisation in Sericulture



Satish Verma & S. B. Dandin

MECHANISATION IN SERICULTURE

Satish Verma, Ph.D

S.B. Dandin, Ph.D

Central Sericultural Research & Training Institute
Central Silk Board
Ministry of Textile - Govt. of India
Mysore 570 008 India

Year of publishing : 2006
Copies : 750
Language : English
Price : Rs. 50/-

Authors

Dr. Satish Verma
Dr. S.B. Dandin

Published by : Director, CSRTI, Mysore

Printing Support : Bheemasen S. Pappu

Printed at : Sri Nandikeshwara Offset Prints, Mysore, India Tel. 0821 2445930

FOREWORD

Mulberry Sericulture is a long practiced farm - based activity in peninsular India in particular, and other parts of the country in general. Indian silks are treasurized world - wide for their luster, motifs, sheen, colours and designs. Today, unlike many other farm - based industries, Indian silk industry faces two major challenges - poor quality of cocoons and high cost of production. We, therefore, must improve our quality of silk, and bring down cost of producing silk to make Indian Silk globally competitive.

High returns and lesser risks in Silk cocoon production has attracted many new farmers to take up Sericulture. The traditional Sericulturists are also upscaling their cocoon production facilities for higher gains. Farmers are adopting new technologies like - more productive varieties of mulberry, higher silk content races of silkworms, cost - effective rearing methods and fool-proof diseases and pest management. This has resulted in improvement in the quality of the Silk and productivity of Silk per unit area. However, the high cost of production is still a major concern which is yet to be overcome.

Today mechanization has become a must in the Sericulture sector mainly for reducing the cost of production of silk cocoons. Since the last few years, CSRTI, Mysore is trying to help farmers to take up Sericulture on a large scale, and bring down the cost of production of silk cocoons. These efforts are highly appreciable. Mechanized cultivation of Mulberry and development of machines to carry out various farm operations could soon be adopted by Sericulturists on their farms to produce mulberry leaf at lesser cost. Similarly, various tools and equipments developed by the Institute will not only help in reduction of drudgery in many cocoon - production operations, but, also in curtailing the cost of production of silk cocoons and better productivity of the labour force.

Mechanization in Sericulture is well timed publication from CSRTI, Mysore, to educate the farmers about the benefits of mechanization and the tools, equipments and machines used for various silk production operations. I am sure that book will help the farmers to go in for mechanized cultivation of mulberry and do work at faster rate but at a lesser cost. It will also assist the farmers to adopt newer tools and equipments for reduction of drudgery and operational costs in silkworm rearing.

With best wishes

Date : 20.04.2006

Dr. H. BASKER, I.A.S.
C.E.O. & Member Secretary
Central silk Board
Bangalore

PREFACE

Many technological advances have taken place in mulberry sericulture over last 10 years. High yielding races of silkworms, productive varieties of mulberry, cost effective methods of silkworm rearing and effective diseases and pest management have made sericulture more lucrative and popular among farmers. We have to do a lot to reduce production cost of silk cocoons. The imported silk which is not only superior in quality than Indian silk is available at lesser prices. Hence, efforts are required to reduce cost of production of Indian silk besides improvement in the quality to encounter menace of imported silk. Under WTO regimes India has left with little option for its silk industry, the cost of production must be reduced and quality of silk be improved.

A major cost of production of silk goes for labour required for cultivation of mulberry and rearing of silkworms. The labour costs are around 60 to 70 % of production cost of silk. Under these circumstances mechanisation can prove as critical and decisive input for reducing the production cost . Apart from it, mechanisation helps to reduce drudgery, obtaining timeliness, getting through work, improvement in working environment and better life to farming community. It has been observed that mechanisation has helped in many countries to check exodus of young rural population and bring more area under cultivation.

This book has been prepared for giving an overall view on need of mechanization in Indian sericulture. The methods for introduction of mechanisation in old mulberry gardens and plantation methods for mechanised gardens are suggested. Various kinds of hand tools and machines are illustrated for benefit of sericulturists. A chapter of farm power and machinery performance and management will assist sericulture farm managers to work out cost of operation of machines and determine cost of production of mulberry leaves.

The authors would like to thank Central Silk Board (CSB) , Bangalore for encouraging them for R&D works for mechanisation in sericulture and bring out this publication. We would like to thank Padmashri Dr. M. Mahadevappa, Ex-Vice-chancellor, UAS Dharwad and Chairman Research Advisory Committee of CSRTI, Mysore for his continuous inspiration, guidance and support in all forms for making mechanisation a dream come true in sericulture. The authors sincerely thank the Indian Council of Agricultural Research, New Delhi and Dr. M.M. Pandey, Project Coordinator, All India Coordinated Research Project on Farm Implements and Machines, Central Institute of Agricultural Engineering, Bhopal for financial and technical support for mechanisation in mulberry cultivation. The authors are also grateful to Dr. Vinita Sharma, Director, Deptt. of Science & Technology, Govt. of India, New Delhi for supporting the research work for reduction of drudgery for women working in sericulture. The authors are also highly thankful to all the staff of Sericultural Engineering Division, Central Mulberry Farm, Rearing Technology and Innovation, and other sections of CSRTI, Mysore for endless support for making mechanisation a reality in sericulture.

As it is the first effort to bring out a book on mechanisation in sericulture, suggestions are invited from readers for improvement in the subsequent editions.

Date : 15.03.2006

Satish Verma
S. B. Dandin

INDEX

S.No.	Content	Page No.
	Foreword	i
	Preface	ii
	Index	iii- iv
Chapter 1	Need and scope of mechanisation in sericulture	1-15
1.1	Introduction	
1.2	Mechanisation and its importance	
1.3	Perspective of mechanisation in India	
1.4	Myths of mechanisation	
1.5	Growth of farm mechanisation in India	
1.6	Need of mechanisation in sericulture	
1.7	Scope of mechanisation in Indian sericulture	
Chapter 2	Mechanisation of mulberry cultivation	16-25
2.1	Farm Prime-movers	
2.2	Space available in the existing mulberry garden	
2.3	Development of mechanised mulberry garden	
Chapter 3	Different types of agricultural tools, equipments and machines and their application in mulberry cultivation	26-57
3.1	Introduction	
3.2	Hand tools for mulberry cultivation	
3.3	Machines for tillage in mulberry gardens	
3.3.1	Types of tillage equipments	
3.3.2	Primary tillage equipments	
3.3.2.1	Country plough	
3.3.2.2	Soil turning plough	
3.3.2.3	Deep soil working equipments	
3.3.2.4	Auger/Post hole diggers	
3.3.3	Secondary tillage equipments	
3.4	Machines for intercultural operations in Mulberry gardens	
3.4.1	Weed control methods	
3.4.2	Weeding tools and equipments	

3.5	Machines for application of chemicals	
3.5.1	Different forms of chemicals	
3.5.2	Chemical application devices	
3.5.2.1	Dusters	
3.5.2.2	Sprayers	
Chapter 4	Special purpose machines for sericulture	58-70
4.1	Mulberry cutting preparation machine	
4.2	Mulberry shoot harvesting machine	
4.3	Knapsack type mulberry shoot harvester	
4.4	Machine for crushing mulberry shoots for composting	
4.5	Seri Torch	
4.6	Mulberry leaf chopping machine	
4.7	Powder Duster	
4.8	Matured silkworm harvester	
4.9	Cocoon deflossing machines	
4.10	Cocoon cutting machine	
4.11	Tray washing machine	
Chapter 5	Economics of Mechanisation	71-77
5.1	Economic performance	
5.2	Costs	
5.3	Examples of calculation of cost of operations of farm prime-movers and machines	
List of the Tool, equipment and machine manufacturers and suppliers		78

Chapter 1

NEED AND SCOPE OF MECHANISATION IN SERICULTURE

1.1 INTRODUCTION

Sericulture, a science based art combining both on farm activity of producing mulberry leaf and indoor activity of rearing silkworms for production of cocoons and raw silk, is a prominent agricultural activity in Karnataka, Tamilnadu, Andhra Pradesh, West Bengal and Jammu Kashmir. India earns over Rs 2,500 Crores every year through export of variou silk products besides being the largest consumer of silk.

Many technological advances have taken place in mulberry sericulture over last ten years. High yielding varieties of mulberry, productive races of silkworms, cost effective methods of mulberry cultivation and silkworm rearing, integrated diseases and pest management systems have made sericulture more remunerative and popular among farmers. Due to high profits, today many large farmers are venturing into sericulture.

Today, Indian silk is facing stiff challenge from imported of silk mainly from China. The Chinese Silk is not only superior in quality than Indian silk but it is also available at lesser prices. The cost of silk production in India is quite high. Hence, efforts are required to reduce cost of production of indigenous silk, besides improvement in the quality to encounter stiff competition with imported silk apart from meeting the demand of silk for domestic consumption.

In India, area under mulberry has reduced during last few years though the silk production has gone up due to adoption of new technologies by the silk cocon producers. Additional efforts and steps are required to be taken up by the policy-makers to halt the recession in silk industry and augment the production of silk besides reducing the production cost.

A major portion of cost of production of silk goes for labour required for cultivation of mulberry leaves and production of cocoons through rearing of silkworms. The labour costs are around 60 to 70% of the total cost of production of silk. The worker's efficiency is very low in India as most of the works are carried out manually or with help of hand tools.

Mechanisation has helped India in a big way by improving the land and labour productivity and reducing the production cost of most the agricultural and horticultural crops. This has also helped in carrying out large scale operations. Mechanisation in sericulture could be a possible way to enhance productivity of land and labour and making it more attractive and economic activity in India that too with large holdings.

1.2 MECHANISATION AND ITS IMPORTANCE

Mechanisation is the art and scientific application of mechanical aids for increasing production and preservation of food and fibre crops with less drudgery and cost. It is not synonymous with automation. Mechanisation is required to provide various inputs to agriculture, agro-processing and rural living for increased production and productivity at reduced cost; provide technology for efficient handling, transport and storage of agricultural produce, processed products and by-products; apply technology and management practices for value addition, agro-employment, assuring better quality of life to rural people, a life that is nutritionally healthy and hygiene wise secured and free from arduous labour and drudgery.

Mechanisation helps in increasing the production, productivity and profitability in agriculture by achieving timeliness in farm operations, bringing precision in metering and placement of inputs, reducing avoidable input losses, increasing utilisation efficiency of costly inputs (seed, chemicals, fertiliser, irrigation water, etc.), efficient use of animal and commercial energy for increased productivity at the same time reducing unit cost of produce, enhancing profitability and competitiveness in cost of operations. The Figure 1.1 shows impact of mechanisation on productivity in Indian agriculture.

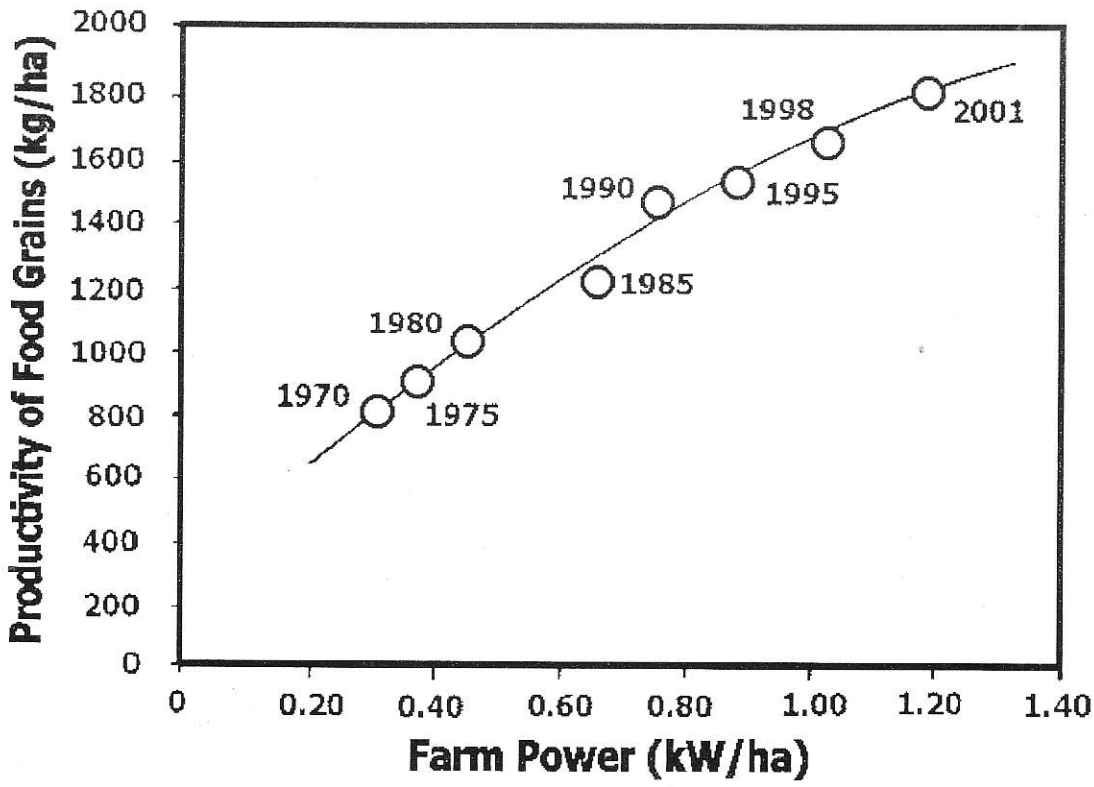


Figure 1.1 : Impact of farm power availability on productivity in Indian agriculture

The mechanisation also helps in conservation of produce and by-products from qualitative and quantitative deterioration, enables value addition and establishment of agro-processing enterprises for additional income and employment from farm produce and development a prosperous economy for meeting rural needs. By reducing drudgery in production and post-harvest operations and providing quality energy to household activities, the mechanisation helps in elevating the quality of life rural populace. Mechanisation has helped many countries to check exodus of rural population and bring more area under cultivation by reducing drudgery, improving efficiency of workers, etc.

1.3 PERSPECTIVE OF MECHANISATION IN INDIA

India is faced with daunting challenges, magnified by ever increasing population and their aspirations, globalisation of markets and frequent economic sanctions. Yet, the food, fibre and nutritional security, income and employment to rural masses are basic needs and have to be assured at all costs. It is expected that the population of India is going to swell by 50% by 2025. The countrymen, therefore, shall gear up to produce adequate food and fibre for all citizens inspite of shrinking of cultivated land.

In India, the size of land holding has steadily reduced over years. The average holding size has reduced from 2.30 ha in 1971 to 1.57 ha in 1991 and 1.05 ha in 2001. The small (1-2 ha) and marginal (below 1 ha) farms numbering 78% of total holdings account for only 32% of the area under cultivation, whereas 20.4% medium farmers (2-10 ha) account for 50.4% of cultivated area, 1.6% of large farms (above 10 ha) account for 17.5% of cultivated area. Therefore, in farm mechanisation strategy there is need for a paradigm shift. New trends, absentee farmers and semi-urban farming are appearing at brisk pace. While on record average holdings may be reducing due to laws of inheritance, the operational land holdings are large enough for mechanised farming as evidenced from Punjab, Haryana and parts of Uttarpradesh, Madhyapradesh, Maharastra, Rajasthan and Gujrat States.

One of the major constraints for low farm production and productivity in India is inadequate of farm power and energy availability. Over different Plans, emphasis have been laid by the Government of India on selective mechanization which has resulted increase in farm power availability from 0.25 kW/ha in 1951 to 1.15 kW/ha in 1997 and 1.23 kW/ha in 2001 (Table 1.1). It is interesting to note that farm power from animate sources has declined from 97 % in 1951 to 16 % in 2001, whereas power from mechanical sources has gone up from 2.1 to 46.5 % and electrical sources from 0.5 to 37.5 %. The availability of draught animals is reducing, thus shortfalls have to be met mostly through electro-mechanical power sources. Inspite of continuous efforts by Government of India, the farm power available per unit area is still very low when compared to developed nations like USA, France, UK, Italy, Germany & Japan.

Table 1.1 : Availability of Farm Power for Indian Farms

Year	Total Power KW/ha	Percentage of		
		Animate Power	Mechanical Power	Electrical Power
1951	0.25	97.4	2.1	0.5
1961	0.31	94.9	3.7	1.4
1971	0.36	79.2	16.3	4.5
1981	0.63	48.2	32.3	19.5
1991	0.92	34.5	34.7	30.8
1997	1.15	22.7	43.5	33.8
2001	1.23	16.0	46.5	37.5

In India, the average farm power is required to be increased to atleast 2kW/ha to assure timeliness and quality in the field operations particularly to carryout out high power requirement operations like sub-soiling, chiselling, deep ploughing, summer ploughing and handle produce and by-products efficiently, process them for preservation and value addition, income and employment. Farm power sources will be utilised efficiently only if we have matching, energy efficient, versatile, sturdy user friendly and affordable equipments and machines.

1.4 MYTHS OF MECHANISATION

The experience of four decades of growth of mechanisation in India has disproved many myths :

(i) Tractors, combines and other heavy machinery will displace labour

India has emerged as leading tractor manufacturing country in World. It produces more than 2.50 lakhs tractors and 40 thousand power tillers annually. Several studies conducted in different parts of country have revealed that, mechanisation has helped in increasing production, productivity, generation of income and employment. Punjab, the most mechanised State in India, employs 10 lakh farm workers from adjoining States out of which half have been employed on regular basis and remaining during the harvesting seasons. Even the socialist dominated State of Kerala has decided to fully mechanise the paddy cultivation in coming three-four years in view of drudgery involved in it and higher labour wages.

(ii) That heavy machines are not suitable for small and medium farmers.

Custom-hiring of high capacity equipment like ploughs, harrows, seed-cum-fertiliser drills, reapers, threshers and combines is becoming very popular. The demand of these machines is increasing day by day. The people who benefit the most from custom-hiring of machines are often small and medium farmers who normally can not afford to buy or do not find owning such machines economical. It is expected that in next 25 years, 50 % of the population will live in cities and towns, increasing the number of absentee landlords and weekend farmers who have to depend mainly on custom-hiring of high capacity and efficient machines.

(iii) Each change in mechanisation must be justified solely by economics

Mechanisation in many agricultural and horticultural crops has helped in improving the productivity of land and labour and also improving the quality of the product, thus reduction in cost of production and higher prices for the produce. In addition to above, the mechanisation has helped in reducing the drudgery in many farm operations, improving farmer and animal health and safety, fulfilling desires and increased dignity of the farmers which are some of the benefits of the farm mechanisation difficult to measure in terms of Rupees.

(iv) Agriculture sector can utilise all the surplus untrained and possibly un-trainable people

Agriculture has emerged as a strong rural industry in India in general and life-line to the people of rural populace in particular. It has played an important role in country's overall development in last two decades. Today, in agriculture only skilful workers are required particularly for adoption of new technologies, improved methods of cultivation and mechanisation of crop production. The untrained and un-trainable people can be absorbed by industries and construction sector where many activities need little knowledge and skill compared to agriculture.

1.5 GROWTH OF FARM MECHANISATION IN INDIA

The land and labour productivity is greatly influenced by the availability of farm power for various crop production and processing operations. The land and labour productivity is higher in most of the developed countries largely due to adoption of new technologies of crop production including farm mechanisation which helps in obtaining timeliness in farm operations, maintaining good tilth in field, precise placement of seed and fertilizer, effective weed and pest control and timely harvesting, transportation and preservation of the crop produce and by-products.

The Indian agriculture is getting increasingly mechanised at a fast pace. The share of mechanical power consisting of tractors, power tillers, diesel engines, electric motors in Indian agriculture has gone up from 21 % in 1971 to 84% in 2001 (Table 1.1). On the other hand, non mechanical power, mainly agricultural workers and draught animals share in overall power used has drastically come down to 16% in 2001 from 79 % in 1971. The total power used in agriculture in 2001 was about 1.23 kW/ha of which mechanical power accounted for 1.03 kW/ha, while non-mechanical power accounted for 0.20 kW/ha.

Tractors alone account for the largest share of farm power in India. In 1971, the tractors contribution to farm power was only 7.5%. It rose sharply over the decade to 19% and 30% in 1991. Currently, tractors accounts for as much as 40% of total share of mechanical power used in agriculture. The demand for the tractors has in fact risen far more sharply than supply. In 10 out of 18 years from 1985-86 to 2002-03, the sales of the tractors have been higher than domestic production. The spurt in demand has raised India's position in tractor ownership to the fourth largest in the world. Indians own over 16 lakh tractors - far higher than the number of tractors in China which owns 8.5 lakh. Only the USA, Japan and Italy have tractors more than India. Punjab, Uttapradesh, Madhyapradesh, Rajasthan, Haryana, Maharastra and Tamilnadu have the high tractor sales and use in India.

The share of power tillers, electric motors and diesel engines in total power consumed by agriculture has gone up as well, but at slow pace than rise in tractor's share. For instance, the share of electric motors has increased from from 4.5% in 1971 to 37 % in 2001. The power from diesel engines used mostly for stationary works like pumping water, operating threshing and processing units, etc. has gone up from 18% in 1971 to 20 % in 2001. The progress made by power tillers which are generally suitable for small and marginal farmers is also significant. The power tillers share to farm power has increased from 0.05% in 1971 to 0.3% in 2001.

The share of draught animals has come down from 79 % in 1971 to 16% in 2001. The share of human power has come down as well from 16% in 1971 to less than 7% in 2001. The mechanisation of agriculture in India is expected to further grow at brisk pace in coming years.

The growth of farm mechanisation in India has been rapid during the last three decades as evident from the energy utilisation by agriculture sector in Table 1.1. India followed a policy of selective and need based mechanisation. It was predominantly in field operations where traditional practices were unable to achieve timeliness of operations. Tractors and other kind of prime-movers, equipments and machines particularly for seed-bed preparation, sowing, irrigation, plant protection and threshing operations have become very popular in India.

(a) Land preparation

(b) Planting

(c) Chemical spraying

(d) Crop harvesting

(e) Threshing of grains

Figure 1.2 :
Mechanisation has taken place at brisk pace in Indian agriculture in many farm activities

There is direct effect of availability of farm power and machinery on productivity of land and labour. Electro-mechanical sources of farm power and energy have supplemented and substituted traditional animate and organic sources. The growth of farm mechanisation in the States of Punjab, Haryana, Uttarpradesh, Maharastra and parts of Rajasthan, Tamilnadu, Andhrapradesh, Gujrat and Madhya Pradesh is at higher rate and so also their productivity levels as compared to national average. There is significant decline in the use of animate energy and a steady increase in the use of mechanical and electrical power. This has resulted increase in farm production and productivity to a greater extent.

1.6 NEED OF MECHANISATION IN INDIAN SERICULTURE

Sericulture comprises of four major activities namely food plant (mulberry) cultivation, silkworm rearing, silk reeling and manufacture and finishing of fabrics. Of the four, former two are land based activities and the remaining two are industrial in nature. In India, Mulberry cultivation, silkworm rearing and egg production are by and large carried out manually. More than half of the cost of cocoon production accounts for production of mulberry leaves. The profitability in sericulture depends mainly on leaf and cocoon yield and also price of cocoons, besides cost of mulberry cultivation and rearing expenses. It has been observed that, profit in sericulture has come down considerably over last few years due to sharp hike in input and operational costs. Moreover, the import of silk from China at a cheaper rate has also influenced the prices of indigenous silk to a greater extent in last two-three years. This makes one to think to reduce cost of production of Indian silk.

To reduce production cost of Indian silk, we must improve labour productivity. The labour output/efficiency in Indian sericulture is very low compared to advanced countries like Japan. The main reason for higher labour efficiency in Japan is high degree of mechanisation and availability of efficient machines for almost all kinds of the activities/ operations. In Japan smart and efficient machines are available and used for operations like land preparation, plantation, intercultural operations, harvesting of leaves and shoots, fertiliser and pesticide application, disinfection, leaf chopping, chawki rearing, late age rearing, separation of matured worms, cocoon harvesting and deflossing, etc. In India most of the activities/operations in sericulture are still being performed manually or with tools and equipments which are not only inefficient but also obsolete.

Sericulture is an unique enterprise where crops are harvested 5 - 6 times a year by repeated pruning and training of mulberry. As a result of this, calendared operations/ activities from pruning of garden to harvest of cocoons has to take place within 60-70 days, hence making it a time oriented practice in the large holdings ensuring timeliness of all activities may not be possible by the manual operations. The activities which have to be completed in shortest time are pruning of a mulberry garden, weeding and cultural

operations, leaf and shoot harvest during 5th instar of silkworms, application of bed disinfectants, picking matured larvae for spinning and cocoon harvest. The availability of large number of workers for a short time is a problem. To overcome the labour problem, we must improve the output and productivity of the workers. This can be achieved through appropriate mechanisation at different stages of cocoon production through adoption of appropriate tools and machines by sericulture farmers.

1.7 SCOPE FOR MECHANISATION IN INDIAN SERICULTURE

The Tables 1.2 to 1.4 present scope of mechanisation in various activities of sericulture. It is evident from these Tables that there is good scope for improving productivity of workers through adoption of tools and machines for carrying out various operations.

Mulberry cultivation

Mulberry cultivation is highly labour intensive. It is estimated that around 800 man-days/hectare/year are required for maintenance of a mulberry garden. From Table 1.2, it is evident that there is good potential for reduction in labour requirement through mechanisation. The overall labour requirement could be reduced to 1/10th through mechanisation. Mechanisation will, therefore, result in significant reduction in cost of production of mulberry leaves, obtaining timeliness in various operations, improvement in quality of leaf and drudgery alleviation. The following activities in mulberry cultivation can be fully or partially mechanised.

1. Preparation of land
2. Preparation of planting material (Cuttings)
3. Intercultural operations
4. Application of manures and fertilisers
5. Irrigation
6. Spraying of chemicals (fungicide/micronutrients, etc.)
7. Leaf/Shoot harvesting
8. Pruning
9. Waste Management for composting

Table 1.2 : Scope for improvement of labour efficiency in mulberry cultivation through mechanisation

Operation	Present method		Improved/Mechanised method		Efficiency Index (A/B)
	Tool used/ method	Mandays Per ha (A)	Machine proposed	Mandays Per ha (B)	
1. Land ploughing/ deep cultivation	Crowbar	100.00	Tractor	2.00	50.00
2. Harrowing	Bullocks	10.00	Tractor	1.00	10.00
3. Pit making	Manual	300.00	Tractor Post hole digger	50.00	6.00
4. Trench making for plantation	Manual	25.00	Tractor trencher	2.00	12.50
5. Cutting preparation	Manual	8.00	Cutting machine	1.00	8.00
6. Fertiliser application	Manual	8.00	Fertiliser applicator	1.00	8.00
7. Spraying chemicals	Hand or Knapsack sprayer	5.00	Power tiller sprayer	2.00	2.50
			Tractor sprayer	1.00	5.00
8. Irrigation	Manual	8.00	Drip or sprinkler	2.00	4.00
9. Shoot harvesting	Manual	50.00	Shoot harvester	5.00	10.00
10. Intercultural operations	Manual	100.00	Power tiller	5.00	20.00
	Bullocks	15.00	Tractor	3.00	5.00
11. Pruning	Manual	60.00	Power tiller operated pruner	10.00	6.00
			Power saw	30.00	2.00

Silkworm Rearing

Silkworm rearing requires timeliness and large number of work force at times mainly for feeding the worms during 5th instar, bed cleaning, picking of matured worms and putting them on mountages for cocooning, harvesting, cleaning and deflossing of the cocoons. If sufficient workers are not available during these specific periods, farmers will face serious problems and this sometimes may result in crop loss. Hence, for assured and timely action, mechanical devices for reduction in manpower are very much required. The Table 1.3 shows the potential for enhancing the labour efficiency in silkworm rearing through mechanisation. High reduction in labour requirement can be achieved through mechanisation of the following silkworm rearing activities :

a. Young age (Chawki) rearing

1. Disinfection and cleaning
2. Leaf chopping and feeding
3. Bed cleaning
4. Dusting of chemicals/Disinfectants
5. Chawki worms packing and transportation

b. Late age rearing

1. Disinfection and cleaning/washing
2. Feeding and cleaning
3. Application of fungicides/bed disinfectants
4. Picking of matured worms
5. Mounting
6. Cocoon harvesting
7. Cocoon deflossing and cleaning
8. Cocoon packing and transportation

Silkworm Egg Production

Silkworm egg production, called commonly as Grainage, is an important activity in sericulture. In India almost all grainage operations are being carried out manually. Very little has been done in India so far for mechanising grainage activities. Table 1.4 shows scope for improving labour efficiency in various grainage activities. The mechanisation will help in high labour savings in operations/activities like :

1. Cocoon deflossing
2. Cocoon sorting
3. Cocoon cutting
4. Sex separation
5. Egg washing, drying and winnowing
6. Examination/Testing of eggs
7. Egg packing and transportation
8. Egg incubation

Table 1.3: Scope for improvement of labour efficiency in silkworm rearing through mechanisation

Operation	Present method		Mechanised method		Efficiency Index (B/A)
	Tool used/ method	Output (A)	Machine proposed	Output (b)	
1. Mulberry leaf chopping for chawki worms (per worker/hr)	Manual	8 kg	Leaf chopping machine	200	16.50
2. Matured worm picking/separation (per worker/day)	Manual	25 dfls	Worm separating machine	150 dfls	6.00
3. Cocoon harvest from rotary mountages (per worker/day)	Manual	25 dfls	Cocoon harvester	200 dfls	8.00
4. Cocoon deflossing (per worker/day)	Manual	10kg	Deflossing Machine	500 kg	50.00

Table 1.4 : Scope for improvement of labour efficiency in silkworm seed production through mechanisation

Operation	Present method		Mechanised method		Efficiency Index (B/A)
	Tool used/ method	Output per day (A)	Machine proposed	Output per day (b)	
1. Cocoon deflossing (per worker/day)	Manual	10 kg	Deflossing machine	500 kg	50.00
2. Cocoon sorting (per worker/day)	Manual	50 kg	Cocoon sorter	200 kg	4.00
3. Cocoon cutting (per worker/day)	Manual	10 kg	Cocoon cutting machine	100 kg	10.00
4. Sex separation (per worker/day)	Manual	5 kg	Sex separator	80 kg	8.00
5. Moth examination (per worker/day)	Manual	500 moths	Automatic moth crusher cum examination machine	10000	20.00
6. Moth crushing (per worker/day)	Manual	5000 moth	Moth crusher	40000 moth	8.00
7. Loose egg packing (per worker/day)	Manual	500 boxes	Egg packing machine	5000 boxes	10.00

Traditional method		Improved/Mechanised method
	Mulberry cutting preparation	
	Intercultural operations	
	Irrigation	
	Shoot harvest	

Figure 1.3 :Traditional methods vs Improved/Mechanised methods for mulberry cultivation

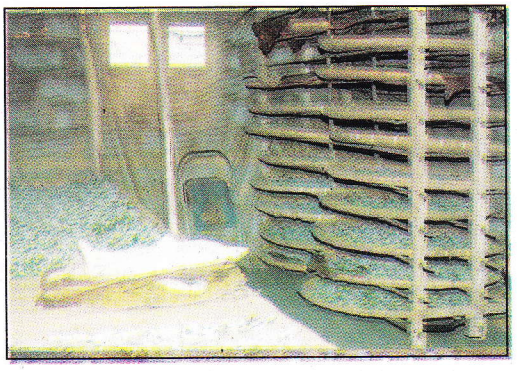
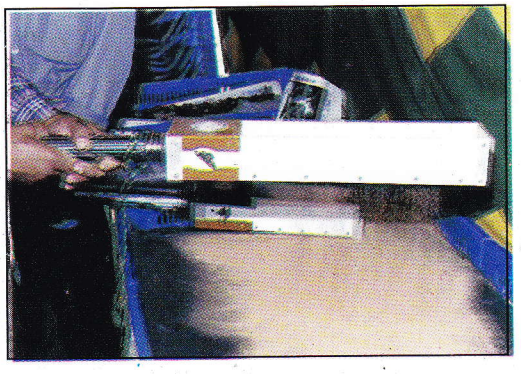
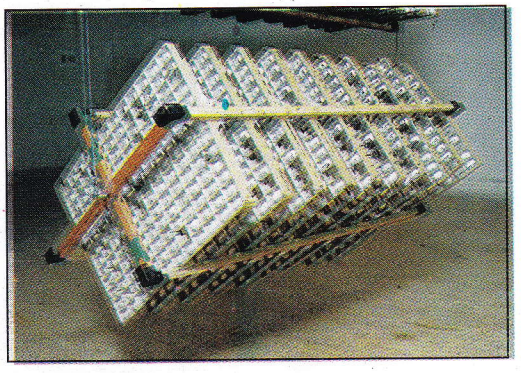
Traditional method		Improved/Mechanised method
	Leaf chopping	
	Silkworm rearing	
	Bed disinfectant application	
	Silkworm mountages	

Figure 1.4 :Traditional methods vs Improved/Mechanised methods for Silkworm rearing

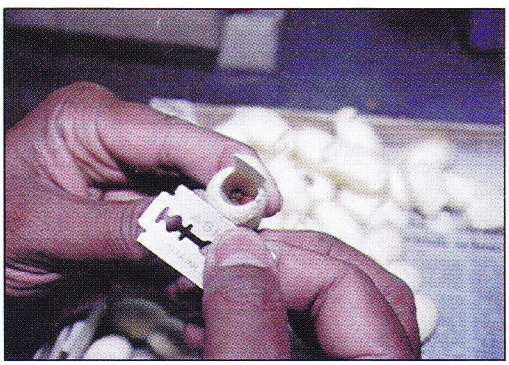
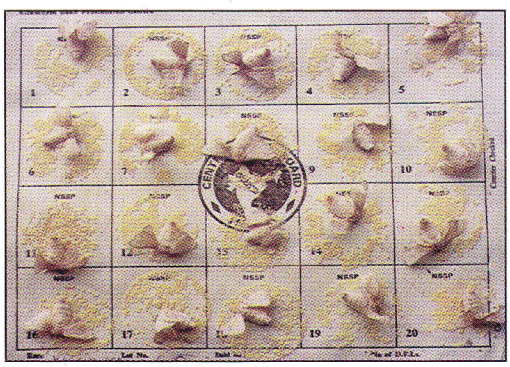
Traditional method		Improved/Mechanised method
	Cocoon deflossing	
	Cocoon cutting	
	Silkworm eggs	

Figure 1.5 : Traditional methods versus Improved/Mechanised methods for silkworm egg production

Chapter 2

MECHANISATION OF MULBERRY CULTIVATION

This chapter tells the readers about scope and the techniques for mechanising existing mulberry gardens and guidelines for the development of new mulberry gardens suitable for mechanisation.

A variety of farm prime-movers such as tractors and power-tillers are available in India. The specifications of these are described in the first section. This will enable a farmer to decide the space to be left between the plants for free movement of the tractors and power-tillers along with different type of machines and implements.

The second section contains details of existing mulberry gardens, space available between the rows after pruning of the plants, growth of plants with respect to variety, age, etc. This will enable the farmer to find out the actual space available between the plants in the existing gardens for free movement of machines and also to decide the width of machines and implements suitable for mulberry cultivation.

The third section presents the scope for mechanisation of existing mulberry gardens and the guidelines for the development of a new mechanised mulberry garden.

2.1 FARM PRIME-MOVERS

In Indian agriculture, tractor is the most popular farm prime-mover. The power tillers are also becoming popular among small and marginal farmers these days due to their multiple utility for land preparation, intercultural operations, pumping water, transportation, pesticide application and other farm works. To use tractors and power tillers in a mulberry garden, one should know the following specifications of the tractors and power tillers.

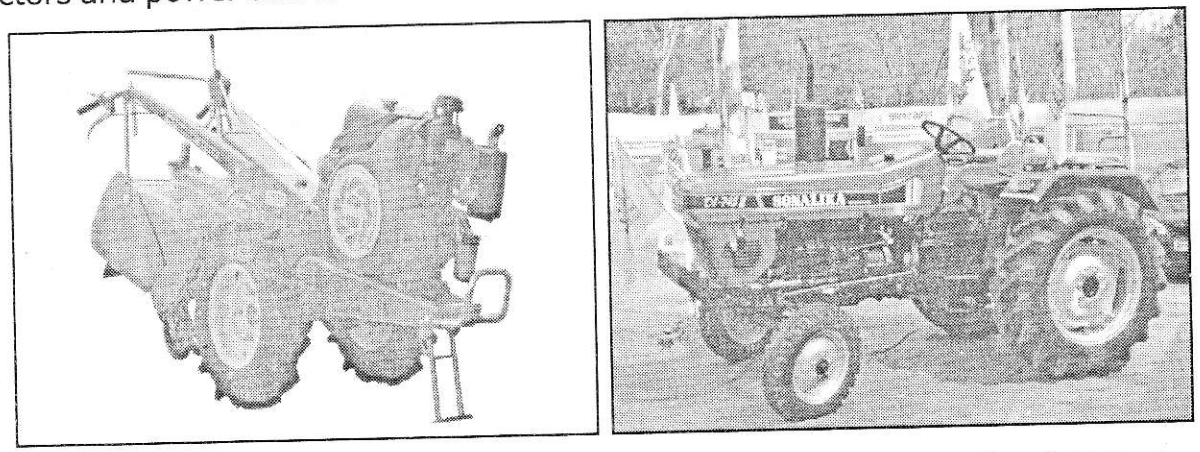


Figure 2.1 : Major source of power on Indian farms (a) Power tiller (b) Tractor

(a) ***Overall width*** of tractor or power tiller helps in determining the minimum space to be left between the rows of mulberry plants for free movement of the tractor or power tiller with a machine or an implement.

(b) ***Ground clearance*** is the clearance between tractor/power tiller body and the ground. This will help in determining the maximum pruning height or the crown height to be maintained for passage of the tractor or power tiller with machine over the plants.

(c) ***Overall length*** of the tractor/power tiller is required for determining the minimum space to be left on sides for turning of the tractor/power tiller.

(d) ***Turning radius*** of the tractor/power tiller should be known to determine the minimum space to be left on sides of the garden for turning of the tractor/power tiller.

Figure 2.2 shows schematic representation of above mentioned specifications. Tables 2.1 & 2.2 contain specifications of some popular makes of power-tillers and tractors manufactured in India.

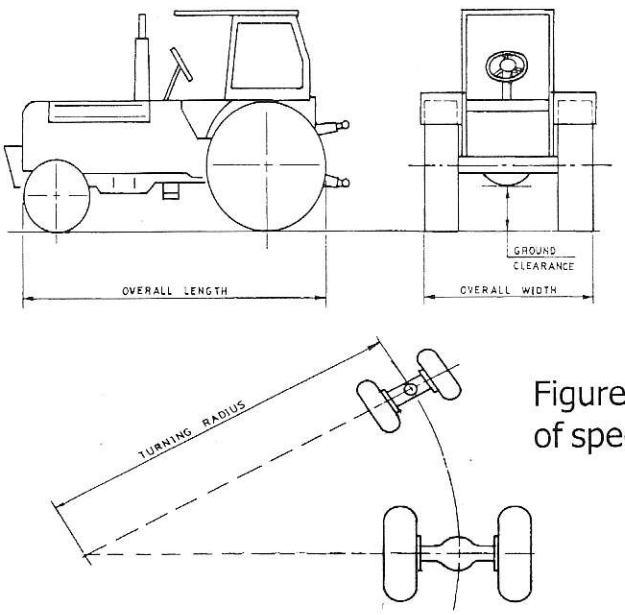


Figure 2.2 : Schematic representation of specifications of a tractor

Table 2.1 : Details of Power tillers

Make	Model No.	hp	Overall Width (cm)	Overall Length (cm)	Ground Clearance (cm)	Turning Radius (cm)
Mitsubishi	CT85/AD8U	8	90	240	20	70
	CT85/VWH120	10	90	240	20	70
KUBOTA	KMB200	12	93	225	20	82

Table 2.2 : Details of Some popular tractors in India

S.No.	Make/Model	HP	Overall length(mm)	Overall width(mm)	Ground clearance(mm)
1	TAFE/Massey Ferguson				
	25 DI	26	3060	1650	320
	30 DI	31	3010	1650	320
	1035	36.5	2990	1650	320
	4410	44	3075	1650	375
	5245	50	3350	1900	335
	5900	60	3590	2000	420
2	Escort				
	3035	27	2600	1680	360
	3036	30	3070	1660	400
	303	35	3070	1690	400
	440	40	3350	1690	360
3	Sonalika				
	S 325	50	3450	1690	445
	S 217	30	3400	1680	380
4	Bajaj Tempo Ltd.				
	300	30	3110	1665	383
	400	40	3340	1675	402
	450	42	3340	1700	402
	500	50	3340	1690	402
5	Mitsubishi/VST				
	Euro VST180D	18.5	2565	930	190
	Shakti MT180D	18.5	2565	930	190
6	HMT				
	2511	25	1980	1740	360
	3511	35	3230	1950	400
	4511	45	3520	2010	390
	5911	59	3700	2250	470
7	Punjab Tractors Ltd. (Swaraj)				
	722	24	3290	1665	405
	724	26.5	3285	1675	385
	733	34	3290	1680	390
	834	34	3440	1675	390
	735	39	3435	1675	390
	939	41	3520	1675	390
	744	48	3438	1730	405
	855	55	3420	1725	400
8	Eicher				
	241	23	3128	1620	375
	242	23	3090	1632	390
	312	36	3125	1625	383
	364	35	3055	1623	340
	368	40	3435	1650	345
	485	50	3430	1710	385
	380	43	3525	1690	315
	480	47	3525	1700	320
	5660	57	3600	1730	328
	6100	68	3685	2050	408

From Table 2.1, it can be seen that most of the power-tillers have power between 6 and 9 KW (8 - 12 hp). The overall width of power tillers is 90 cm (3'). The ground clearance for all power tillers is 20 cm (8"). The overall length of different makes of power tiller vary from 200 cm (78") to 240 cm (96"). The turning radius for power tillers ranges from 70 cm (28") to 82 cm (33").

The tractors are generally classified as small tractors (up to 20 hp), medium tractors (20-50 hp) and high capacity tractors (above 50 hp).

From Table 2.2, it could be seen that there is only one manufacturer of small tractors in India. Small tractors are still not very popular in India as they have been introduced only few years back and have limited application on a farm. In India, a tractor on a farm is used mainly for operating a variety of machines and implements for farm works such as breaking-up or opening of uncultivated land, ploughing, harrowing, seeding and transplantation, intercultural operations, harvesting, threshing of crops, pumping water, running processing units and most importantly and largely for the transportation of farm inputs, construction materials and rural people. A small tractor has limitations in doing all these works. This is the main constraint for poor response of farmers towards purchase of small tractors. For sericultural work, small tractors could be quite useful, particularly for maintenance of gardens, intercultural operations and transportation of farm inputs and materials. The spacing in a mulberry garden should be made to suit the operation of small tractors. At present only few type of equipments are available in market for small tractors making their use further limited. The producers of Mitsubishi tractors are manufacturing few implements such as rotavator, cultivator, etc. Hence, there is a need for development of other matching equipments for the small tractors to augment their utility and popularity.

The medium sized tractors are very popular in India as they meet almost all types of the work and transportation requirement of the farmers and a variety of matching implements and equipments are also available for these tractors. Indian farmers generally prefer tractors of 30-40 hp. A variety of tractors with wide network for after-sales service and matching implements are available all over India. There are very few farmers doing sericulture alone in India. On most of the farms, sericulture is also one of the many farm activities, particularly in Southern Indian States. Farmers can utilise the available tractor with the available implements in the mulberry garden. For medium sized tractors, implements for all kind of farm operations are available. The details and utility of these for mulberry cultivation are described in Chapter 3. The overall width of medium sized tractors is 170 - 180 cm (5.5' - 6'), ground clearance 35 - 40 cm (14" - 16") and turning radius 250 to 300 cm (8' - 10').

Large sized tractors have very limited use in Indian agriculture. They are used mainly for land development and material transportation. Large tractors could be utilised for heavy field works such as opening-up of the new land for cultivation, ploughing, etc. but such works are carried out occasionally on a farm. On the developed farms, large tractors do not have much utility. Moreover, the average size of land holdings in India, particularly for sericultural works, does not justify the ownership of a large tractor.

2.2 SPACE AVAILABLE IN EXISTING MULBERRY GARDENS

To find out feasibility of mechanisation in existing mulberry gardens, it is essential to know the actual space available between the rows after the pruning or shoot harvest so that tractor and power-tiller operated machines and implements can carry out operations such as weeding, pesticide application, etc. without causing damage to the plants. Table 2.3 shows the free space available between the rows in mulberry gardens of different ages. It could be seen that the space available between the rows decreases gradually with the age of plants. For high yielding varieties such as S-36, the space reduces to less than 50 cm (20") between the rows for 90x90 cm (3'x3') plantation after 2-3 years of age, which makes mechanisation in close spacing plantations such as 60x60 cm (2'x2') and 90x90 cm (3'x3') difficult with the kind of tractors and power-tillers and their matching machines and implements available in India. From Table 2.1, it can be seen that width of power-tillers is 70-85 cm in most of the cases. Hence, for the free movement of power-tillers along with machines for various operations in a mulberry garden, a minimum gap of 120 cm (4') should be maintained between the plants. A gap of 150 cm (5') should be left on the sides for turning of the power-tiller with machines such as cultivators, rotavators, etc.

Table 2.3 : Space available between the rows in a mulberry Garden

Age of Plantation (Years)	Space available between the rows (cm)	
	60x60 cm (2'x2') plantation	90x90 cm (3'x3') plantation
Variety : K2		
years onward	50 x 50 cm	60 x 60 cm
3 - 4	40 x 40 cm	60 x 60cm
4 - 5	40 x 40 cm	45 x 45 cm
5 - 6	35 x 35 cm	40 x 40 cm
above 5 years	35 x 35 cm	40 x 40 cm
Variety : S36		
2 - 3	-	55 x 55 cm
4 - 5	-	45 x 45 cm
Variety : V1		
2-3 years		60 x 60 cm
4-5 years		50 x 50 cm

From Table 2.2, it could be seen that, overall width of medium sized tractors (30-40 hp) is around 170 cm. Hence, the space between the plants in a mulberry garden should be at-least 180 cm (6') for free movement of the tractor alongwith machines. The field trials showed that a space of 240 cm (8') should be left on sides for easy turning of the tractor with a machine. In case of a paired-row plantation, described in Section 2.3, for operation of tractor operated machines, a minimum gap of 120 cm (4') should be provided between the pairs of mulberry plants.

2.3 DEVELOPMENT OF MECHANISED MULBERRY GARDENS

From Sections 2.1 and 2.2, it is learnt that for operation of tractor and power-tiller operated machines and implements, a minimum space of 120 cm (4') is required between the plants after pruning or shoot harvest. Under these circumstances, it may not be feasible to mechanise cultivation in traditional spacings such as 60x60 cm (2'x2') and 90x90 cm (3'x3') plantations or any other type of plantations having plant to plant or row to row spacing less than 120 cm (4'). Therefore, for mechanisation in mulberry gardens where plant to plant or row to row spacing is less than 120 cm , it is required to increase the gap between the rows to a minimum of 120 cm (4'). However, the operation of tractor or power-tiller could be made possible in the existing close spacing gardens in the following manner :

For 60x60 cm (2'x2') plantation

In 60x60 cm (2'X2') mulberry garden, uproot every third row to convert garden into a paired row system or each alternate row to create 120 cm (4') gap between the rows for easy passage of a tractor or a power-tiller with an implement (Figure 2.2). Figure 2.4 shows a 60x60 cm (2'x2') mulberry garden converted to a paired row system with spacings as 60x120+60 cm (2'x4'+2').

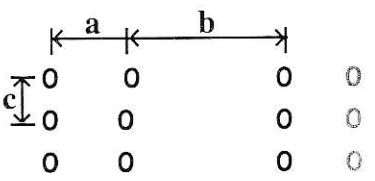
For 90x90 cm (3'x3') plantation

The same way as done in the case of 60x60 cm (2'x2') plantation.

For a mechanised mulberry garden, the space between rows should be equal or more than 120 cm (4'). In place of single row plantation, paired-row plantation could be taken up for maintaining adequate plant population. Details of some paired-row plantations for mechanized cultivation using standard power-tiller and tractor are given in Table 2.4. The plant population for a paired-row plantation could be determined from the following expression :

$$P = \frac{20000}{(a+b) \times c}$$

Here P : No. of plants per hectare
a : space between two rows in meters
b : space between two paired rows in meters
c : space between plants in meters



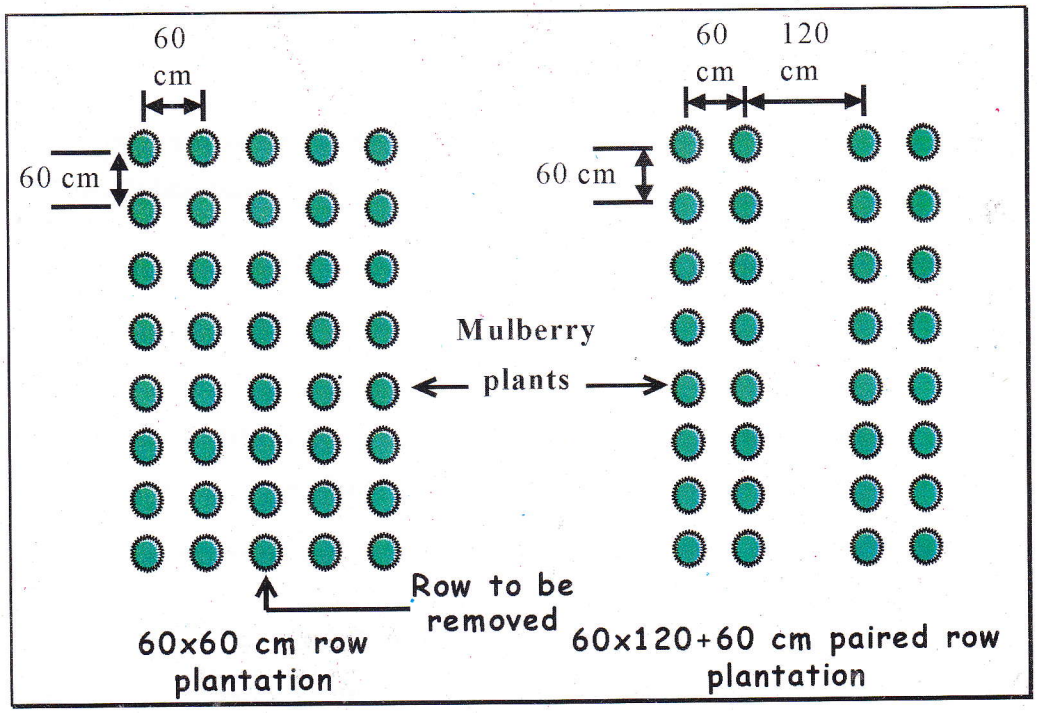
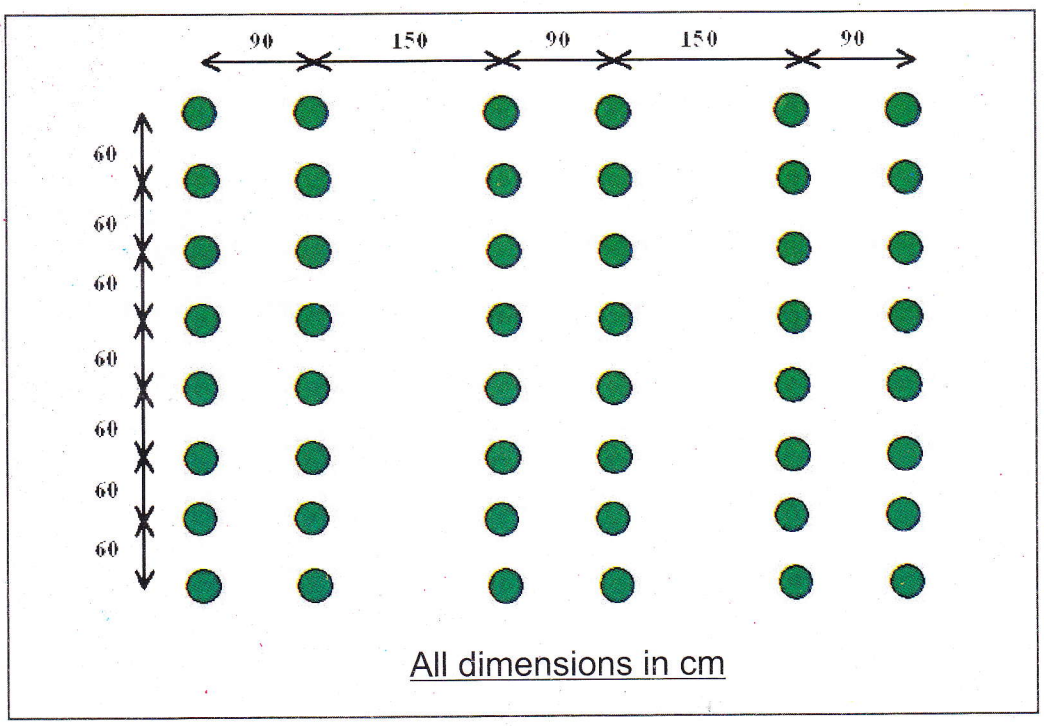


Figure 2.3 : Method for converting a 60x60 cm or 90x90 cm mulberry garden into a paired row plantation

Figure 2.4 : Tractor operation in 60x60 cm mulberry garden converted into a paired row system



Plant arrangement in a typical Paired Row Plantation

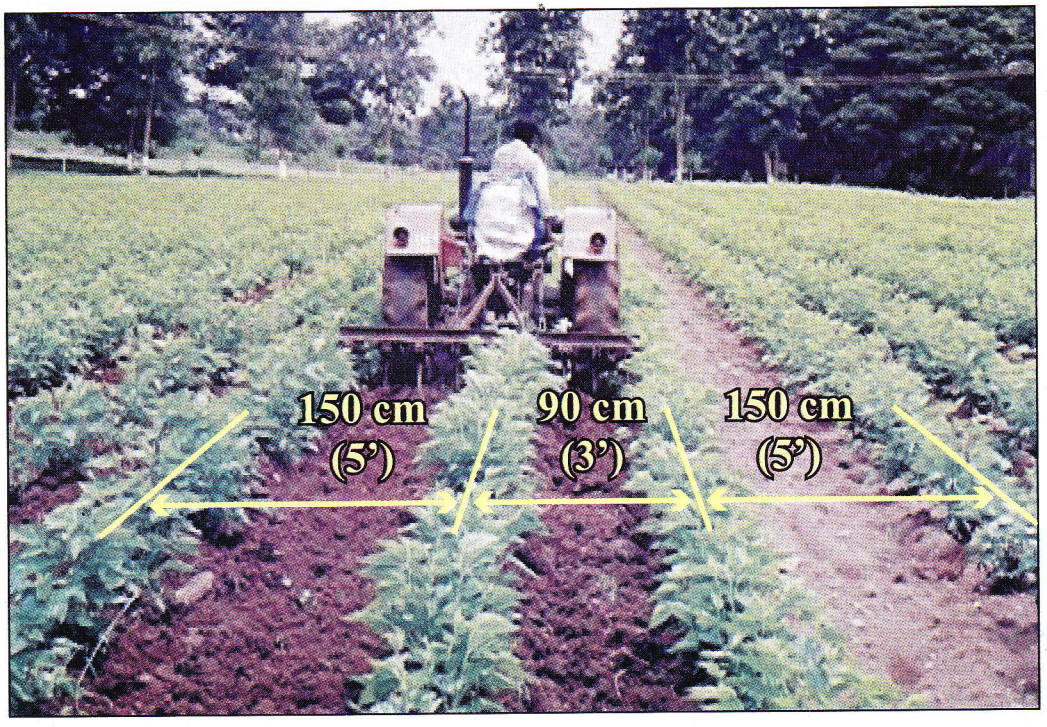


Figure 2.5 : A typical paired-row mulberry plantation for mechanised cultivation

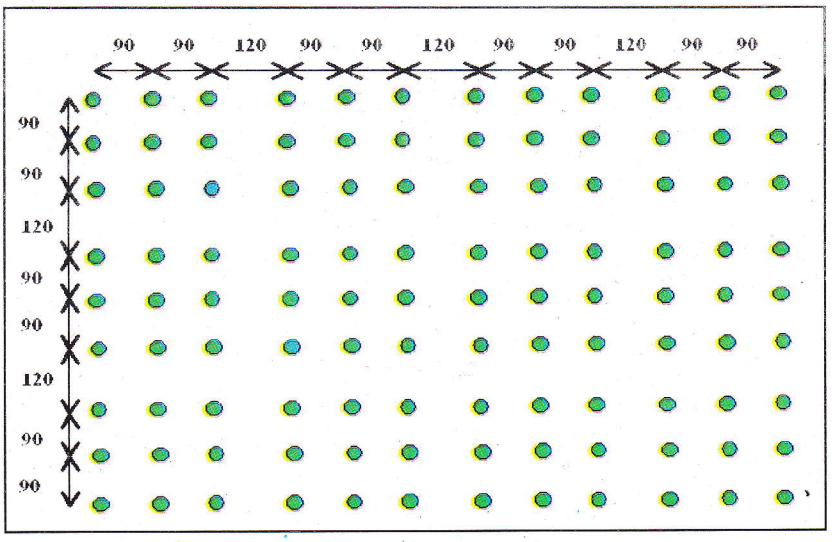
Table 2.4 : Plant population in a paired-row garden for different spacings

Space between rows (cm) (a)	Space between pairs(cm) (b)	Plant population per hectare for plant to plant spacing (c)			
		45 cm	60 cm	75 cm	90cm
60	120	24691	18519	14815	12346
75	120	22792	17094	13675	11396
90	120	21164	**15873**	**12698**	10582
60	150	21164	15873	12698	10582
75	150	19753	14815	11852	9877
90	150	18519	**13889**	11111	9259

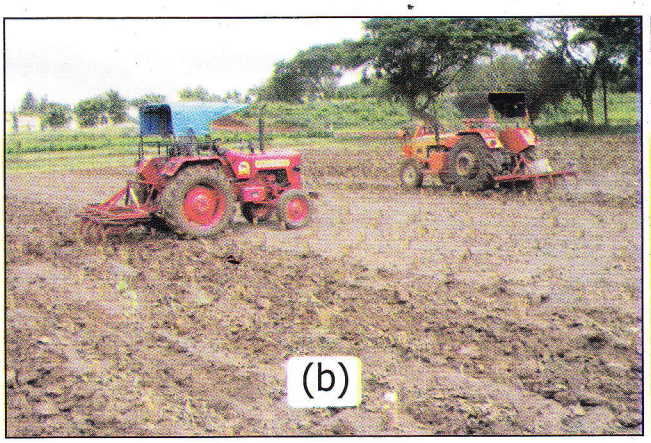
Note : Plant population/ha for 3'x3' is 12345. The spacings marked in dark are well suited for mechanised cultivation and recommended.

The paired row system has many advantges such as plant population higher than 3'x3' plantaion, operation of tractor and power tillers is possible, saving in cost of irrigation systems like drip, less cost of cultivation, etc. The only limitation with paired row plantation is that tractor and power tiller movement is possible only along the rows. Difficulties are faced in removal of weeds between the plants in a row. Hence, farmers use country plough for intercultural operations. This makes a farmer to use both tractor and bullock ploughs for maintenenance of garden. To overcome this problem and provide full mechanisation in mulberry gardens a new plant geometry called 3M (3'x3' modified) has been developed by CSRTI, Mysore (Figure 2.6). Here, the tractor and power tillers can move along and across the rows thus reducing time and cost of maintenance of mulberry gardens. About 2.5 - 3 hours/ha are required for carrying out intercultural operations with tractor. The area occupied by a plant is 1.032 sqm (10 sqft) and the plant population is 9,688 plants/ha in 3M plantation.

(a)



All dimensions in cm



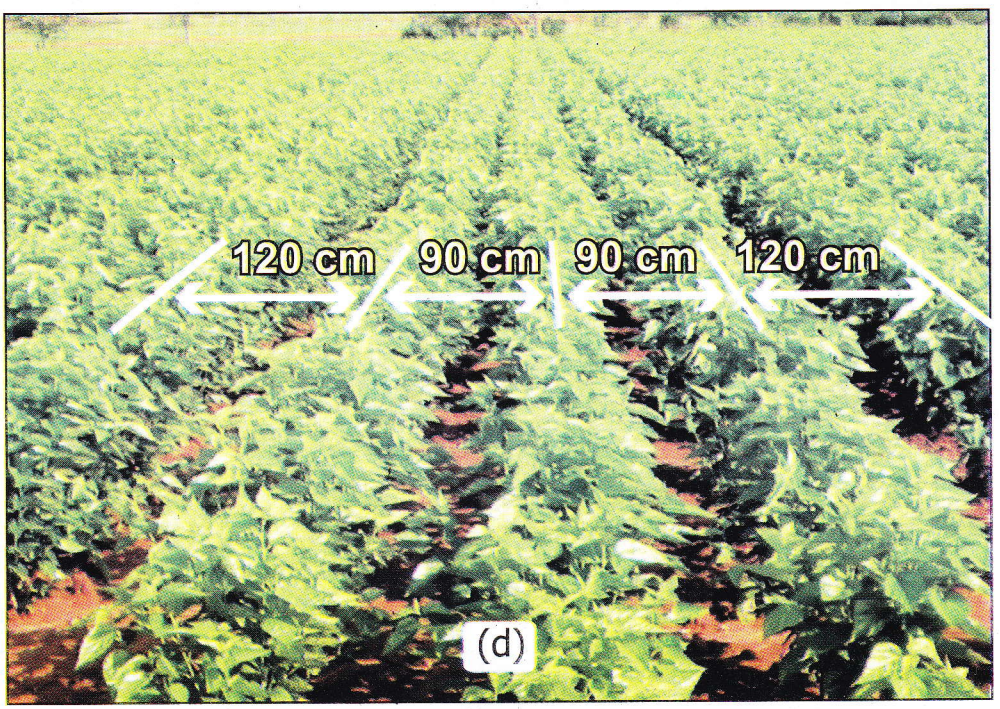


Figure2.6 : 3 M plantation (a) Plant arrangement (b) a week after shoot harvest (c) 25 days after shoot harvest (d) well grown 3M mulberry garden

DIFFERENT TYPES OF AGRICULTURAL TOOLS, EQUIPMENTS AND MACHINES AND THEIR APPLICATION IN MULBERRY CULTIVATION

3.1 INTRODUCTION

In this chapter, different kinds of agricultural tools, equipments and machines available in India, their salient features, capacity, etc. are described besides suggesting their application for mulberry cultivation. Various agricultural tools and machines have been divided in different categories given as below from operation point of view.

1. Hand tools for mulberry cultivation,
2. Machines for tillage in mulberry gardens,
3. Machines for inter-cultivation operations in mulberry gardens
4. Machines for application of chemicals in mulberry gardens.

3.2 HAND TOOLS FOR MULBERRY CULTIVATION

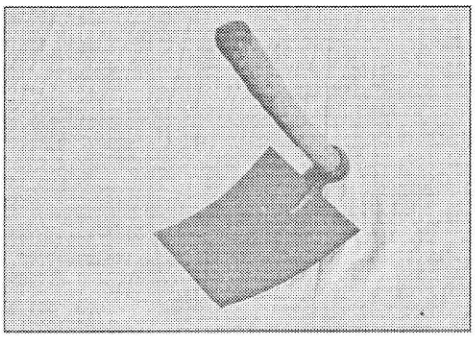
A variety of hand tools are available in India and many of them are used for mulberry cultivation. Some common hand tools used for mulberry cultivation are shown in the Figure 3.1 and described as below :

(a) **Spade :** It is very useful multipurpose hand tool. It is used for digging pits, making furrows, etc. The blade is made of steel and fixed to a wooden handle. Usually, the edge is self sharpening.

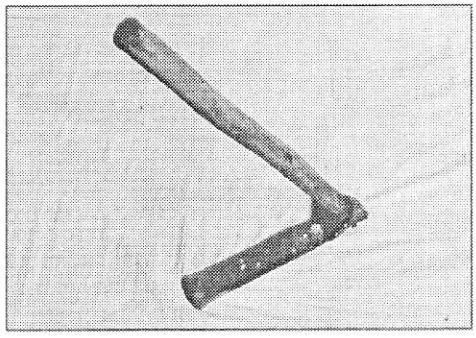
(b) **Hoe :** It is a very common agricultural hand tool used largely for digging around plants. It consists of a narrow and thick iron blade sharpened at one end. A light bend is provided in the blade at centre for easy penetration into soil. For mulberry cultivation, hoe is very important and is used frequently by farmers for weeding, digging around plants and uprooting old mulberry plants apart from many other works.

(c) **Bill Hook :** It consists of a thick curved steel blade. It is used for cutting thick branches. In sericulture, farmers use bill hook for making cuttings.

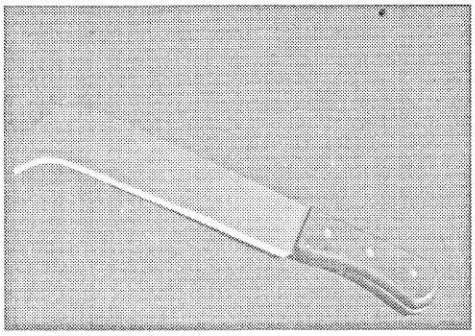
(d) **Sickle :** Sickle is the most common agricultural tool used by farmers all-over India. It is used for various purposes such as harvesting of almost all type of crops; cutting grasses, forage for animals, branches of trees, etc. A sickle consists of a curved sharpened blade of iron or steel. One end of the sickle is



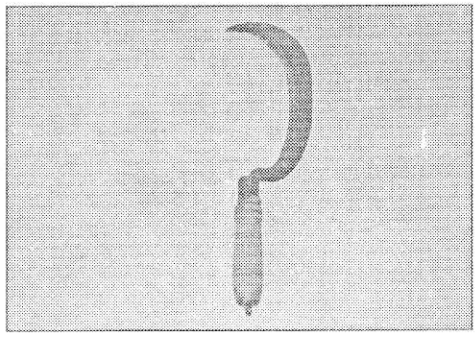
Spade



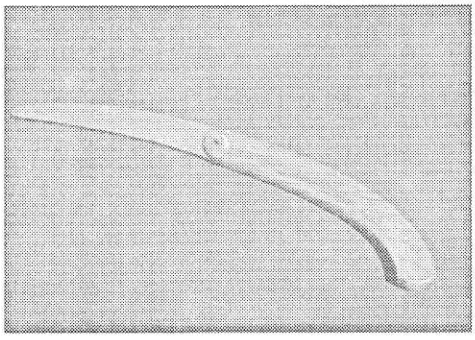
Hoe



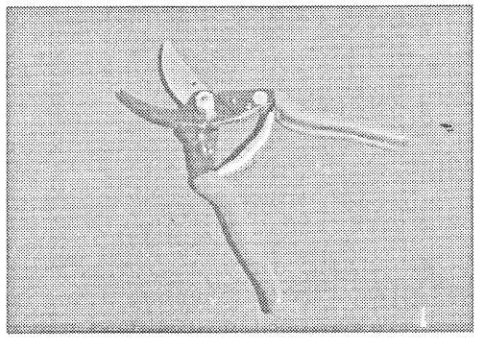
Bill Hook



Sickle



Pruning saw



Secateur

Figure 3.1 : Different kinds of hand tools used for mulberry cultivation

pointed whereas other is fixed to a wooden handle. In India, sickles of various shapes and sizes are available. Serrated sickles have also been introduced to farmers but they could not gain much popularity due to their limited use.

(e) **Pruning Secateur :** It is a very important tool and is used commonly for pruning and cutting soft branches. It is made of special quality steel.

(f) **Pruning Knife/Saw :** This is the most common hand tool used in India for pruning of mulberry and harvesting of mulberry shoots. It consists of a long and curved knife with serrations fixed on a wooden handle. The teeth need to sharpened frequently to reduce cutting effort.

3.3 MACHINES FOR TILLAGE IN MULBERRY GARDENS

Tillage may be defined as the mechanical manipulation of the soil. Some of the objectives of tillage are :

1. To develop a desirable soil structure for a root-bed. A granular structure is desirable to allow rapid infiltration and good retention of moisture into soil, to provide adequate air capacity and moisture exchange within the soil, and to minimise resistance to root penetration and growth.
2. To control weeds or to remove unwanted crop plants (thinning of plants).
3. To manage plant residues. Thorough mixing of trash is desirable from the tilth and decomposition standpoint, whereas retention of trash in the top layers checks soil erosion.
4. To minimise soil erosion by following practices such as contour tillage, listing and proper placement of trash.
5. To establish specific surface configurations for planting, irrigation, drainage, harvesting operations, etc.
6. To incorporate and mix fertilisers, pesticides, or soil amendments into the soil.
7. To accomplish segregation. This may involve moving soil from one layer to another, removal of rocks, stones and other foreign objects, or root harvesting.

Tillage operations are classified as primary or secondary tillage, although the distinction is not always clear-cut. A primary tillage operation constitutes the initial, major soil working operation; it is normally designed to reduce soil strength, cover plant materials and rearrange aggregates. Secondary tillage operations are intended to create refined soil conditions and desired tilth after primary tillage.

3.3.1 TYPES OF TILLAGE EQUIPMENTS

Primary tillage equipments are classified as :

i) Country plough (Indigenous or country plough)

ii) Soil turning ploughs

iii) Sub-soiler

iv) Auger diggers

Secondary tillage equipments are classified as :

i) Harrows

ii) Cultivators

iii) Sweeps

(iv) Trencher

3.3.2 PRIMARY TILLAGE EQUIPMENTS

Different type of plough commonly used in India may be grouped as either indigenous plough or soil turning plough.

3.3.2.1 Country Plough

Country plough is used both as primary as well as a secondary tillage implement for upland and wetland cultivation throughout India. There are over 40 or more type of country ploughs used in India with large variations in their shape, size and weight to meet the tillage requirements of various types of soils and crops. Figure 3.2 shows components of a country plough. When the plough is pulled forward, the shoe and the share enter the soil, it cuts a furrow slice. A portion of the soil rides over the shoe but larger portion is pushed on sides. After the plough has moved ahead leaving the furrow behind, some portion of soil falls back to the furrow. A country plough cuts a trapezoidal furrow and leaves some unploughed land between two adjacent furrows. To plough almost every bit of land, the country plough has to be used three times i.e. lengthwise, crosswise and diagonally. To plough one hectare of land, about 72 working hours (nearly 10 to 12 days) are required and the ploughman has to walk over 200 km behind plough. This is one of the major drawback of a country plough. Hence, the country plough is well suited only to the farmers having small holdings.

In mulberry gardens, country plough is used by most of the farmers after pruning for inter-cultural operations and weed control. Figure 3.3 shows use of a country plough in a mulberry garden. The country plough is very well suited for small mulberry gardens with narrow plant spacing like 60x60 cm or 90x90 cm. The advantage of country plough is that it can be suited to all spacing. The constraints with country plough are shallow depth of ploughing and time taken for ploughing.

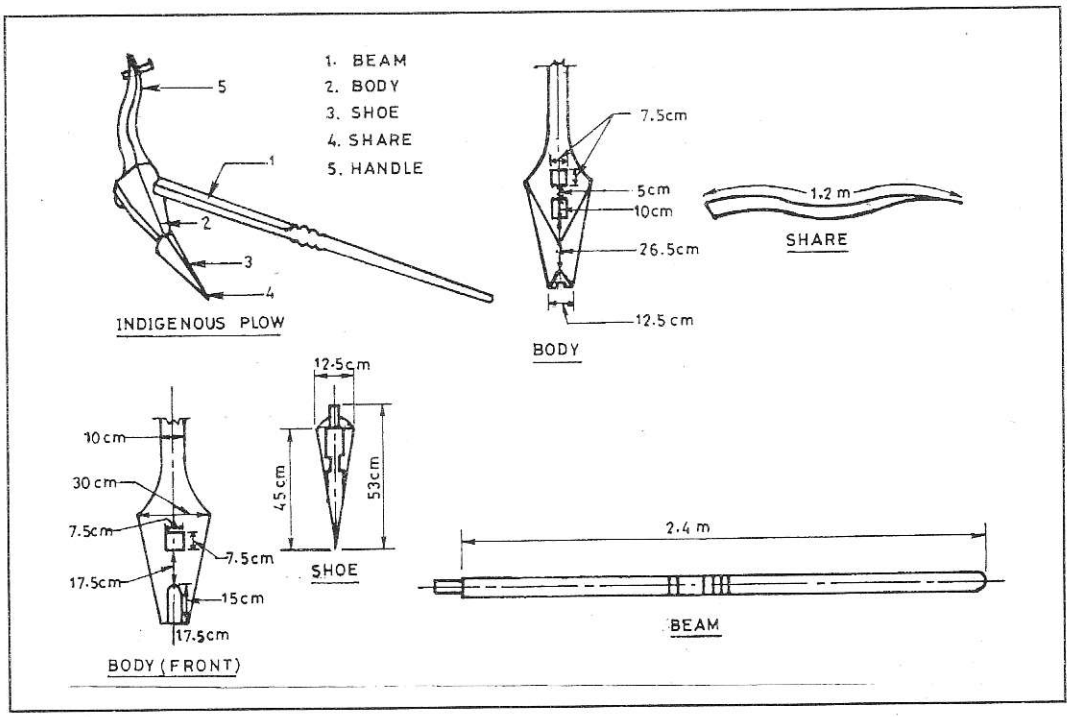


Figure 3.2 : Components of a Country Plough

Figure 3.3 : A bullock drawn plough carrying out intercultural operations in a mulberry garden

3.3.2.2 Soil Turning Ploughs

Mould-board and disc ploughs arethe two types of soil turning ploughs. These could be utilised for land preparation for the establishment of new mulberry gardens.

(a) Mould-board Plough

The mould-board plough is the most important implement used by the farmers for opening of the land in heavy soils and the fields infested with weeds. In one operation, the plough inverts the soil, buries the trash, weed or green manure and granulates the soil, allowing air, moisture and tender roots of plants to penetrate easily. In general, this plough is used in areas having sufficient rainfall. Mould-board ploughs are available as single bottom (animal drawn and power tiller drawn) and multi-bottom (Tractor drawn). A mould-board plough has two main parts - plough bottom and accessories. The Figure 3.4. shows a tractor operated mould board plough. The Mould-board is designed to work itself and is often used without attachments. However, there are a number of attachments that may be used to help the plough bottom in doing effective ploughing. Some useful plough attachments are:

i) Rolling coulter ii) Jointers iii) Gauge wheel

The mould-board ploughs are specified by the number of bottoms and width of cut of each bottom. Approximately, 9 to 11 KW (12-15 hp) is required to pull one bottom plough having width of cut as 30-35 cm. Mould-board plough could be used for primary tillage operations like land preparation for the establishment of new mulberry garden particularly in black and heavy soils.

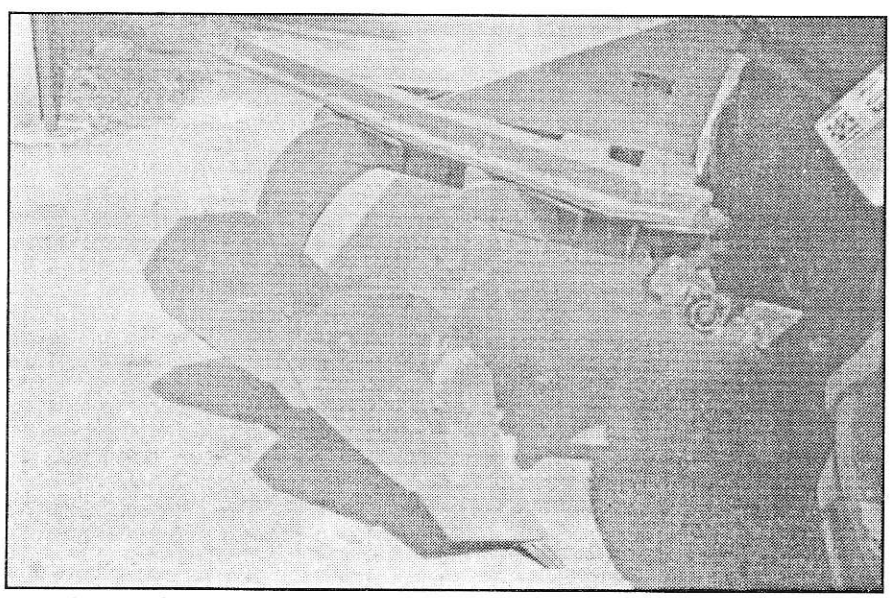


Figure 3.4 : A Tractor Operated Mould-Board Plough

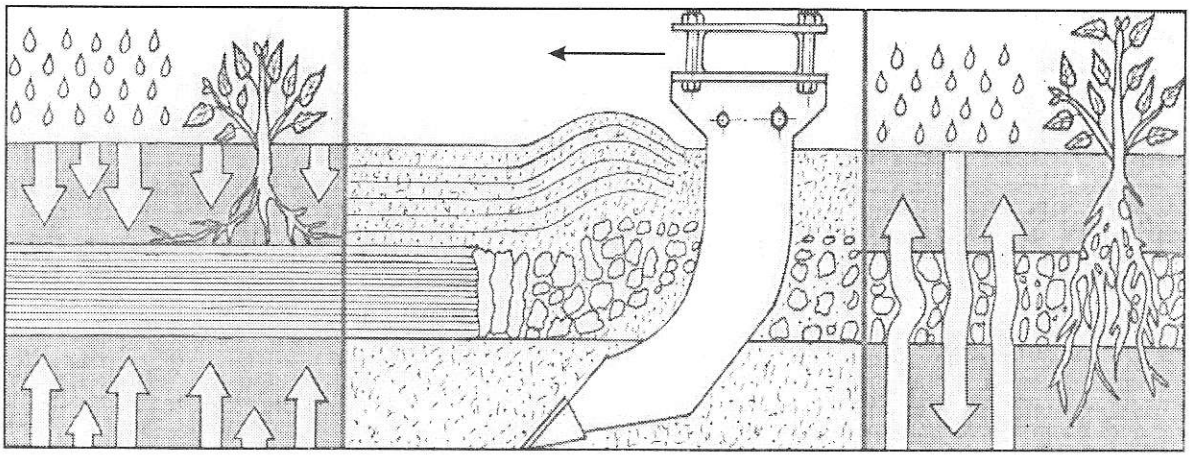
(b) Disc Plough

Disc plough is a primary tillage implement designed to work in all type of soils. It is specifically useful in hard, trashy, stony or stumpy land conditions. Disc plough has better scouring and could be used where mould-board can not be used satisfactorily. Disc ploughs are generally operated by tractor due to high pulling force (draught) requirement and heaviness of the implement. Figure 3.5 shows a tractor operated disc plough. Disc blades are the major components which penetrate into the soil and perform the ploughing. The discs are concave. The concavity of discs permits the penetration of plough and movement of soil over it. The discs are specified by its diameter and thickness. A 30-35 hp tractor can pull disc plough with two discs in most of the soils. Disc plough can be used for land preparation for the establishment of a new mulberry garden in almost all type of soils except heavy soils and soils infested with weeds and deep roots.

Figure 3.5 : A Tractor Operated Disc Plough

3.3.2.3 Deep Soil Working Equipments

Sub-soiler and chisel plough are deep soil working implements. In India, mulberry is generally cultivated in the form of bushes. The normal life of a mulberry plantation is around 15 years. Cultivation operations are frequently carried out in a mulberry garden for controlling the weeds and pests, incorporating compost and fertilisers with the soil, etc. These operations lead to formation of an impervious layer over a period of time at a depth of 50 to 60 cm, known commonly as hard pan (Figure 3.6). The hard pan restrict movement of air and water in soil and offers resistance to penetration/growth of the roots. As a result during rainy days, water stagnates in the root-zone causing yellowing of the leaves and decaying of the roots. Overall, the plant growth is adversely affected. The hard pan also reduces the deep percolation of rain water in the soil. This results in water run-off, which not only erodes the soil but also carries off precious soil nutrients with it. The soil erosion reduces the fertility status of the soil and the land gradually loses its top soil thus making land infertile.



(a) (b) (c)

Figure 3.6 : (a) Formation of a hard pan in soil (b) Breaking of hard pan by sub - soiler (c) Increased root activity, air and water movement in soil after sub - soiling

Further, it also leads to poor drainage due to accumulation of toxic salts which ultimately change the soil pH level. The process of formation of hard pan is faster in the clayey soils in comparison to sandy soils. It is highly desirable to break the hard pan from time to time for better growth of the plants, rapid moisture movement in the root-zone, increase in the water holding capacity of the soil, improvement in the drainage and reduction in soil erosion.

Mulberry needs about 125 cm (50 inches) of water per year. Hence, it will be very useful to harvest the maximum amount of the rain water and store in root-zone so that the plants can use it later. This will reduce the water and energy requirement for the crop, hence reduction in the cost of cultivation.

A tractor operated sub-soiler (Figure 3.7) is an agricultural equipment used largely for breaking the hard pans and deep soil cultivation. It also develops cracks in the soil thus increases the soil air, moisture movement and develop vertical root system. Overall, it helps to create an improved soil environment for plant growth. It also helps in :

- reducing water logging and chemical accumulation in sub soil.
- aerating the soil.
- minimising the soil erosion.
- loosening the compacted soil.
- conserving the moisture and thus, moisture is retained in the soil profile for a longer duration.

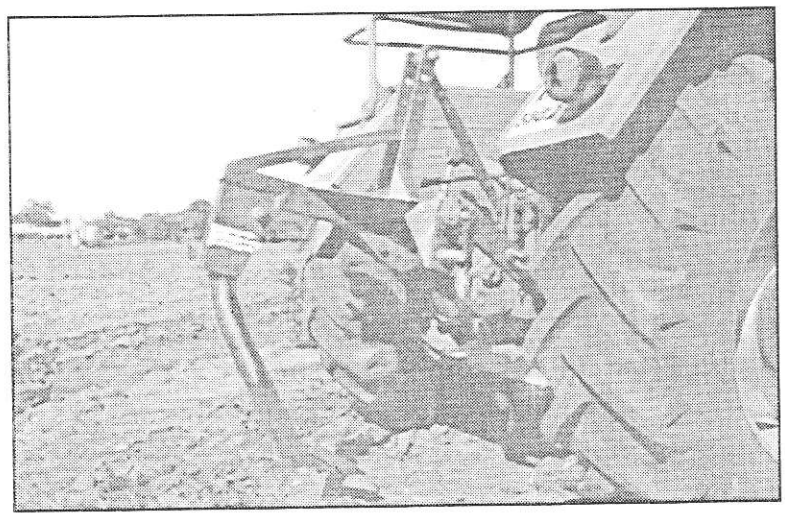


Figure 3.7 : A tractor operated sub-soiler

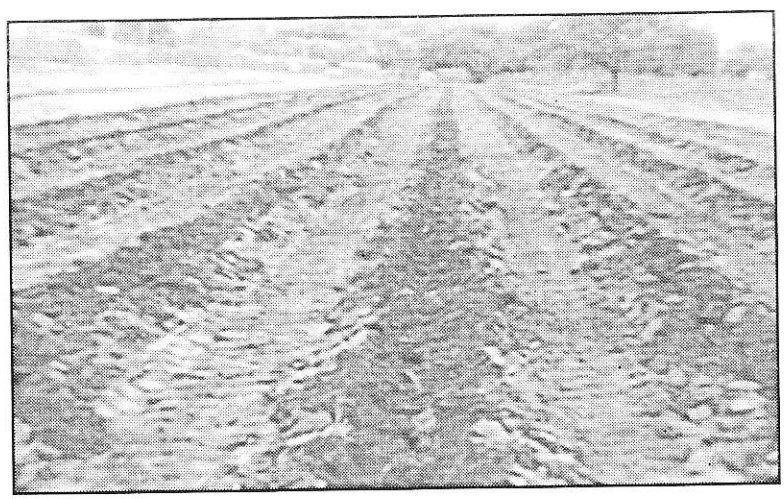


Figure 3.8 : Trenches opened by a sub-soiler in the field for plantation of mulberry

Description of a tractor operated Sub-soiler

A sub-soiler consists of a long and narrow shank with a wedge shaped point (Figure 3.7). It could be mounted at the back of 30 -35 hp capacity tractor. A subsoiler costs about Rs. 10000 and available with the manufacturers and suppliers of the agricultural equipments. When a sub-soiler is operated in the field, it makes trenches filled with loose soil. The maximum depth of a trench is 70 cm. The Figure 3.8 shows a view of the trenches opened by a sub-soiler in a field under preparation for mulberry plantation.

The most ideal time for the operation of a sub-soiler is after pre-monsoon showers so that the maximum amount of rain water could be harvested and conserved in the soil. If the soil is dry and hard, one should wait for good rains so that the soil becomes soft and easily workable. The dry and hard soils need more energy to work with it and hardness of the soil may cause fast wear and tear to the sub-soiler. The fields full of stones and infested with the thick roots should be avoided for sub-soiling.

Application of sub-soiler for mulberry cultivation

A sub-soiler has been found as an effective tool for water harvesting and in-situ moisture conservation in the rain-fed and irrigated mulberry gardens as well. It can also be utilised for opening trenches for the plantation of mulberry saplings. A considerable amount of time and energy can be saved through use of a tractor operated sub-soiler.

Sub-soiling operation can be carried out as a part of land preparation work for the plantation of new mulberry gardens. This operation is highly beneficial as it loosens and aerates the soil. The trenches should be opened in accordance with the spacing at which mulberry saplings are to be planted (Figure 3.8) and should be left open for few days for absorbing the rain water. The saplings can be planted in the trenches. The survival and growth of the saplings is very high and establishment of garden is fast. Vigorous growth of the mulberry plants takes place due to availability of sufficient moisture and air in the soil. The moisture distribution in the soil is uniform. The excess soil water percolates to the lower depth and recharges ground water. The utilisation of sub-soiler also saves the time, money and energy for making the pits for plantation of the mulberry.

An interesting phenomenon takes place in the field where trenches are opened with a sub-soiler. The trenches work as small dams in the mulberry garden and check water run-off in the field. Almost entire rain water is absorbed by the loose soil in the trenches. Practically, the water run-off is negligible. The conservation of the rain water in root-zone also reduce irrigation requirement of the plants in dry spells during the rainy season and increase interval between two irrigations. In the existing gardens, subsoiler should be operated once in two or three years to loosen the soil and check the formation of a hard pan.

Under the rain-fed conditions, where most of the rain water generally goes waste as run-off without much infiltration into the soil, the sub-soiling operation will be very useful, as mulberry plants have a very high water requirement. Overall, a tractor operated sub-soiler is an effective and economic tool for harvesting and conserving the rain water and minimising the water and energy requirement for irrigation of mulberry crop.

3.3.2.4 Auger/Post Hole Diggers

In India, mulberry plants are raised either as tress or bushes. The mulberry saplings are planted in pits or trenches made manually. Making pits or trenches is a time consuming and expensive process. Over one-third cost of establishment of a new mulberry garden accounts for making pits or trenches. Making trenches or pits manually is practicable in a small area but for plantation in a large area, it is essential to use equipments for making pits or trenches due to involvement of high costs. The equipments for making pits are called post hole diggers or auger diggers. In India, tractor and power tiller operated auger diggers are readily available.

(a) Power tiller operated auger digger

Figure 3.10 shows a power tiller operated auger digger. It is a standard unit and can be mounted in the front of a power tiller. The digger consists of a spiral auger actuated by a rack and pinion arrangement. With this arrangement auger can be moved up and down. The energy for the auger is provided through a transmission system comprising of belt, pulleys and a bevel gear set. The entire assembly is mounted on a rigid frame with necessary bearings. A wheel handle is provided for depth control. The equipment is provided with a augers of different diameters such as 22.5 cm (9") and 30 cm (12"), etc. The augers operated at 425 - 450 rpm. The cost of a power tiller operated auger digger is about Rs. 8000. It can dig about 30 to 35 pits/hour. The auger digger can be used for making pits for plantation of mulberry, horticultural crops, forest plants, fencing poles, marking stones, etc.

Figure 3.9: A power tiller operated auger digger

(b) Tractor operated auger digger

The figure 3.10 shows a tractor operated auger digger. It consists of a spiral auger driven through bevel gears by the tractor power take off (p.t.o) shaft provided with a shear bolt torque limiter. The auger operates at a speed of 120-130 rpm.

Figure 3.9: A tractor operated auger digger

A minimum 25 KW (35 hp) tractor is required for the operation of an auger digger. The auger points are replaceable. The augers of various diameters such as 22.5cm (9"), 30cm (12") and 45cm (18") are available. The auger digger can make pit up to a depth of 90cm (3').

The tractor operated auger digger makes basin like structure for efficient water harvesting and conserving rain water.

The number of pits made per hour depends upon the type and condition of soil. The saplings can be planted in pits made by auger digger. A saucer basin formed around the plant immediately. The saucer type structure collects the rain water. The in-situ water harvesting and moisture conservation help in quick establishment of plants. The loose soil facilitate root growth. The cost of a tractor operated auger digger is about Rs. 50,000 and the cost of operation worked out to Rs. 200/hr. Although, high initial cost, the equipment is highly cost effective and fast for making pits. It will help farmers in taking up mulberry plantation at large scale and overcoming scarcity of workers for making pits. The drudgery in making pits can also be avoided. The tractor operated auger digger can also be utilized for plantation of horticultural crops, forest plants, installation of fencing posts and marking stones, etc. The tractor operated auger digger is a faster, safer and economical means for making pits for several purposes.

3.3.3 SECONDARY TILLAGE EQUIPMENTS

Harrows are the most common secondary tillage implements used in India. The basic function of harrows is to supplement the work of plough by pulverising, levelling, smoothening and compacting the root-bed. The harrows could also be utilised for weed control on fallow fields, orchards and to a limited extent as weeders or cultivators for growing crops. There are three main types of harrows available in India. They are disc, spike tooth and spring tyne harrows.

(a) Disc Harrow

The function of disc harrow is to pulverise and pack the soil, leaving a surface mulch and compact sub-surface soil. It is also used before ploughing to break soil crust and for mixing trashes with the top soil. Sometimes, it is used in place of a plough because of its deep penetration, as a primary tillage implement. A disc harrow consists of a series of concave disks mounted on a shaft. The shaft along with discs is known as gang. The discs are positioned at equal distance on a shaft with help of spools. The disk harrows can be classified :

According to source of power as :

i) Animal drawn

ii) Tractor drawn

- mounted type
- semi mounted type
- trailed type

According to gang configuration as :

single action type
double action type
off-set type

Figure 3.11 shows details of gang configuration in different type of disc harrows. Disc harrows can be utilised for land preparation for the establishment of a new mulberry garden.

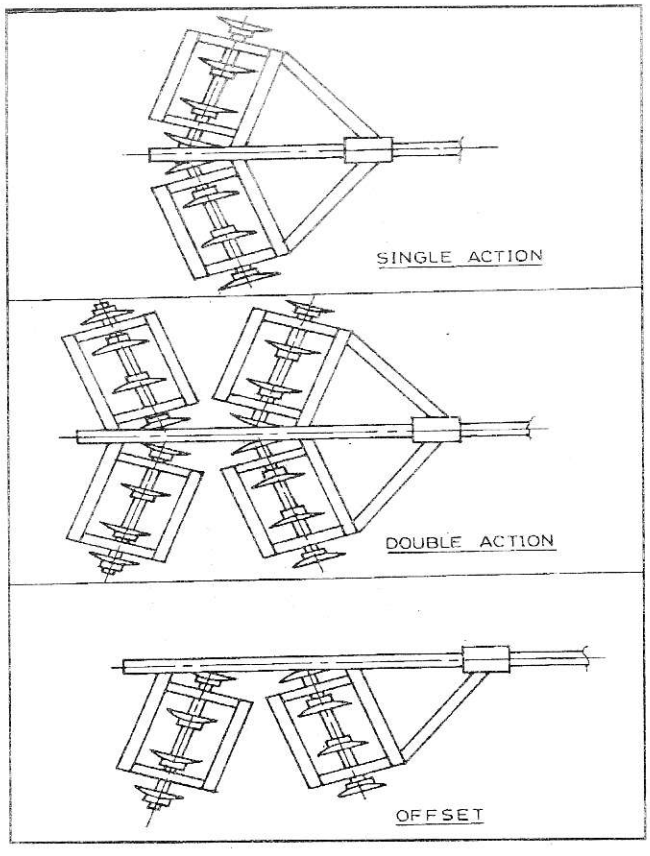


Figure 3.11 : Arrangement of discs in different type of disc harrows

(b) Spike Tooth Harrow

The main use of spike tooth harrow is to smoothen the field surface after ploughing. The teeth provided on it break up the clods and lumps left by the plough, compact the soil and fill the air spaces. It is difficult to use spike tooth harrow on the fields covered with trash, stalks and weeds. It does not penetrate deep in hard soils. The penetration could be increased by adding weight to the harrow. Spike tooth harrows are available in India as animal and tractor drawn units. Oscillating type spike tooth harrows are also used in India but their availability and use are limited. Figure 3.12 shows a spike tooth harrow and its components. A spike tooth harrow could be utilised for preparation of nursery bed for raising mulberry saplings.

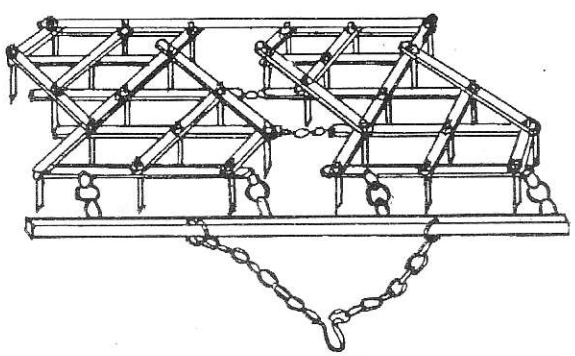


Fig 3.12 : Spike tooth harrow

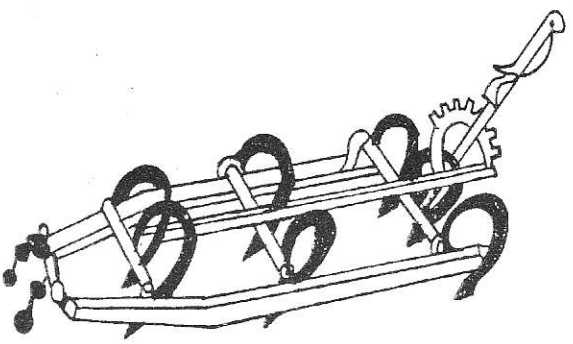


Fig 3.13 : Spring tyne harrow

(b) Spring Tyne Harrow

They are used for harrowing the hard and stony soils. The spring action of tyne prevents the teeth from damage and breaking due to obstruction from stones, roots, etc. The spring tyne harrow is very effective in controlling noxious grasses or weeds that are propagated by roots. The deep penetration of tynes tears out the roots and brings them to surface from where they could be collected by hand or mechanically or could be left on surface for sun drying. Figure 3.13 shows the components of a spring tyne harrow. Animal and tractor drawn spring tine harrows are available in India.

(d) Cultivator

A cultivator is a common tillage equipment used by farmers in India. The main action of a cultivator is soil manipulation by which the following primary tillage objectives of cultivation are achieved :

i) Retention of moisture by killing weeds, loose mulching & retaining rainfall

ii) Aeration of soil

iii) Promotion of microbial activities in the soil

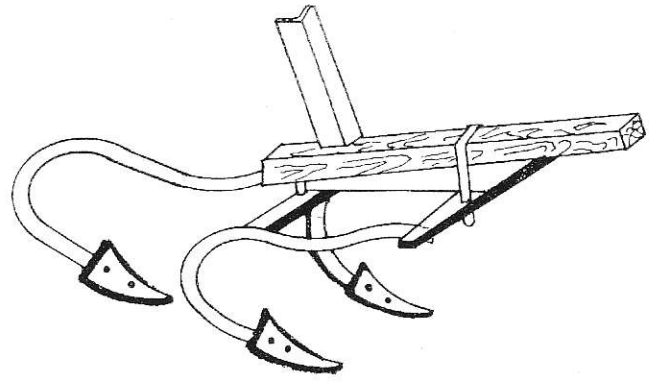


Figure 3.14 : An animal drawn three tyne cultivator

Type of Cultivators

The cultivators are classified as follows on the basis of source of power for their operation.

i) Animal drawn ii) Tractor drawn iii) Power tiller drawn

Animal drawn cultivators are basically of three types :

i) Tool bar type ii) Zigzag type iii) 3 or 5 tyne cultivator

They contain 3 to 5 tynes, attached to frame. Reversible shovels are attached to the tynes. The spacing between the tynes could be varied according to the space between the rows of the crop plants. Figure 3.14 shows an animal drawn three tyne cultivator.

The tractor drawn cultivators could be classified as :

i) Trailed type ii) Semi mounted type iii) Mounted type

In India, mounted type cultivators are very popular and largely used by farmers for different field operations such as tillage, inter-cultural operations, etc. Cultivators can be equipped with different kind of soil working tools such as shovels, sweeps, etc. In India, 9 or 11 tyne cultivators are commonly used. The tynes are either fixed type or spring loaded. The spring loaded tynes are preferred over fixed type as they protect the implement by lifting tine from soil whenever it encounters an obstruction such as stones, roots, stumps, etc.

Power tiller cultivators are also available in India. These cultivators contain 5 rigid tynes (2 in front and three at back). The penetration of the cultivator in soil can be increased by adding weight to the cultivator. The power tiller operated cultivator is very effective and cost economic equipment for inter-cultural operations and weed control in mulberry gardens. Figure 3.15 & 3.16 show the power tiller and tractor operated cultivators.

Figure 3.15 : A power tiller operated cultivator

Figure 3.16 : A tractor operated cultivator

(e) Blade Harrow

Blade harrow is used for primary as well as secondary tillage operations, specifically in black soils. It consists of a blade, prongs for holding blade, wooden body and beam (Figure 3.17). As it is pulled by a pair of bullocks, it scrapes the soil while moving forward. In a mulberry garden, the blade harrow can be utilised for intercultural operations between the rows particularly in the rainfed areas where top soil shall not be disturbed to conserve soil moisture.

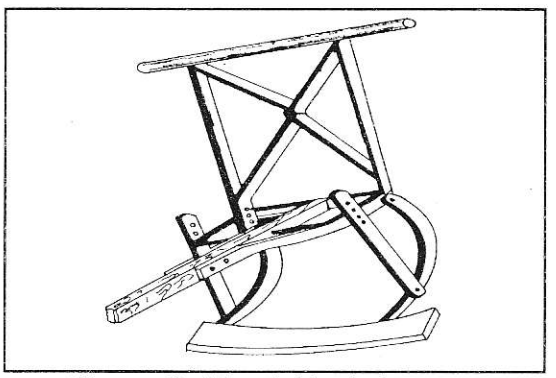


Figure 3.17 : A blade harrow

(f) Rotavator

A rotavator is used for seed-bed weed control, primary and secondary tillage in upland and wetland, etc. It consists of blades, varying in shape and size, mounted on the periphery of a rotating shaft. The shaft gets power and drive from tractor p.t.o or power tiller transmission unit as the case may be. The power tiller operated rotavators is a very effective and efficient equipment for intercultural operations and weed control in mulberry gardens. Figure 3.18 & 3.19 show power tiller and tractor operated rotavators. A good tilth is created in the field when rotavator is used. The only adverse effect of continuous use of a rotavator is that it compacts the sub-soil to some extent which however could be decompacted by periodic operation of a sub-soiler.

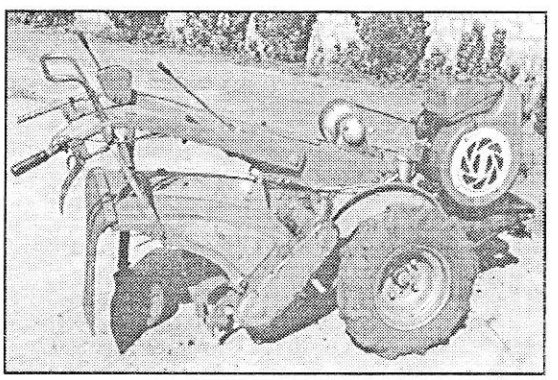


Figure 3.18 : A power tiller rotavator

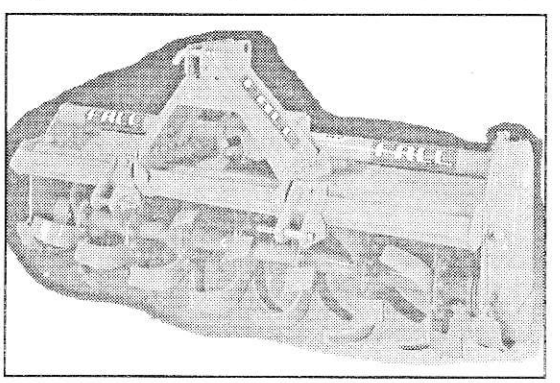


Figure 3.19 : A tractor rotavator

(g) Sweeps

Sweep or duck foot cultivator is basically used in dry land farming for retention of moisture and destruction of weeds. Sweep cultivator consists of a frame and rigid tynes to which sweeps, resembling the duck foot, are attached (Figure 3.20). Sweeps are fast wearing parts and hence are made interchangeable. Sweeps are available for animal, power tiller and tractor drawn cultivators.

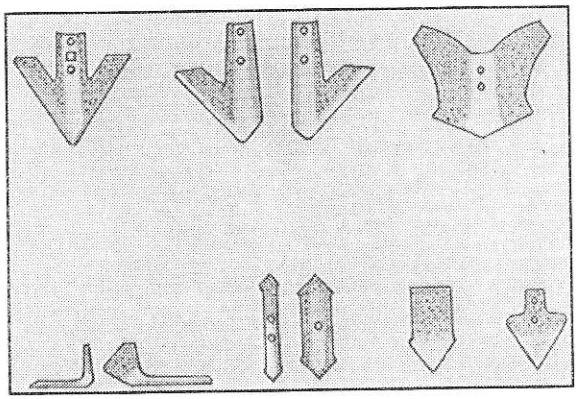


Figure 3.20 : Different types of sweeps

(h) Trencher

Trencher is an implement used for formation of trenches for plantation of crops such as potatoes, sugar-cane, mulberry, etc. and various other purposes such as irrigation channels, etc. in well tilled soils. Various kinds of trenchers operated by bullocks, power tiller and tractor are available. Figure 3.21 shows a tractor operated trencher. This trencher opens up a trapezoidal section furrow. The trenchers can also be used for making trenches for laying pipes, cables, etc. In mulberry gardens, the trenches are very useful for in-situ vermin-composting and harvesting rain water.

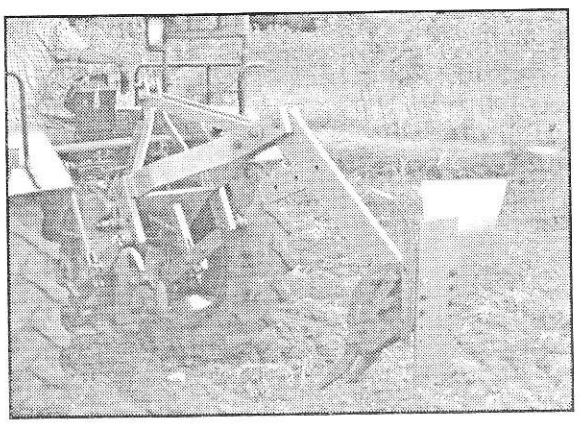


Figure 3.21 : A tractor operated trencher

(i) Bund Former

The bund former consists of two blades attached to a frame (Figure 3.22). The gap between the blades is more in the front and continuously narrows towards the rear. It is generally used for making basins for irrigation in crops like wheat, barley, maize, etc. The size of the bund could be varied by varying space between the two blades. In India, animal. power tiller and tractor operated bund formers are available.

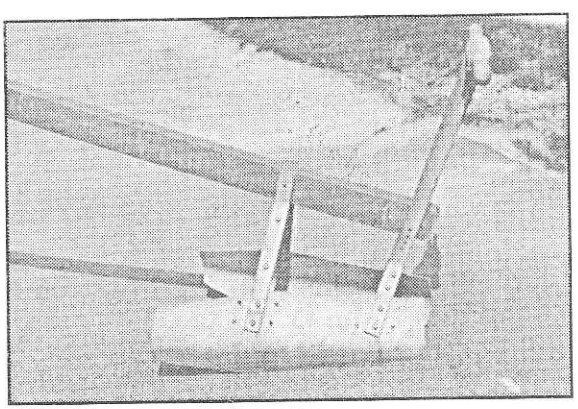


Figure 3.22 : A bullock drawn bund former

3.4 MACHINES FOR INTERCULTURAL OPERATIONS IN MULBERRY GARDENS

Inter-cultivation is one of the essential farm operation for successful mulberry crop and input utilisation. The weed control is a time and energy consuming operation. Of the total man power required for raising mulberry crop, the major portion is spent for controlling weeds as they deprive the crop plants of nutrients and water, often serve as alternate hosts to insects and other pests, detrimental to the crop.

3.4.1 Weed Control Methods

The weed control methods for mulberry could be classified as mechanical, chemical & biological methods.

The mechanical method of weed control has been widely used for mulberry. It involves uprooting or destroying weeds with help of hand tools and equipments operated by man, animals or tractor.

In chemical method, herbicides and weedicides are widely used for control of weeds at various stages of mulberry growth. A number of chemicals are now available which, when applied to the soil at correct rates, will destroy certain type of weeds and grasses. A herbicide may be selective or non-selective. There are some difficulties in the chemical weed control like their long time effects on the soil, difficulties in local availability of genuine chemicals, difficulty in training farmers to handle and store the chemicals safely, non-availability of chemical application equipments, etc.

In biological methods, certain insects feed on the weeds without affecting the crop are introduced to suppress the weed growth. Trap crops are also used sometimes for preventing insects from feeding on the main crop.

Mechanical weeding with the help of simple hand tools and implements is convenient, quick and easy method for crops planted in rows. Efforts have been made in recent years to design and develop better tools and equipments for weed control in various crops. These can also be utilised in mulberry gardens directly or after little modifications.

3.4.2 Weeding Tools and Equipments

Improved weeding tools and equipments used in India could be classified according to power source as manual weeders, animal drawn weeders, tractor drawn weeders, power tiller operated weeders & self-propelled weeders.

(a) Manual Weeders

The manual weeders such as weeding hoe are used for loosening the roots of weeds and thus help in uprooting the weeds. The main drawback with these tools is that once the weeds grow taller, the weeding operation becomes very difficult. Long handle weeders designed ergonomically are also available for weeding and shallow digging and could be utilised for weeding mulberry gardens.

Figure 3.23 shows a V-blade hoe which is used for intercultural operations and weeding in row crops. It weighs around 1.5 to 2 kg. Its long handles enables a person to work in standing posture. A person can do weeding and hoeing of 0.1 to 0.2 hectare per day with V-blade hoe.

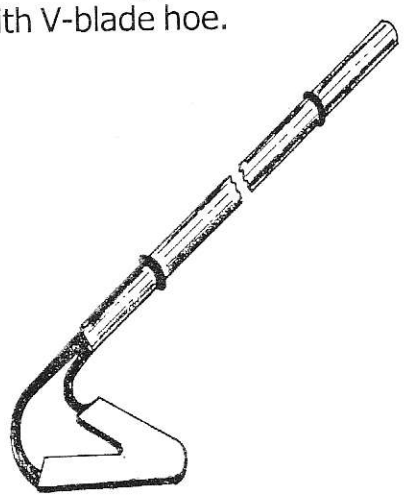


Figure 3.23 : A V-blade hoe

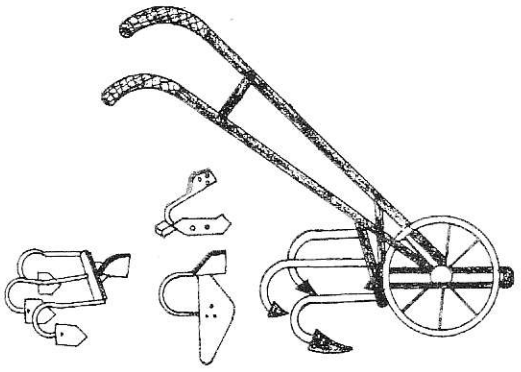


Figure 3.24 : A hand wheel hoe

(i) Hoe

Hoe is useful for removing the weeds in all kinds of soils. It is available in different shapes, sizes and weight.

(ii) Hand Wheel Hoe

The hand wheel hoe is a very popular tool which is used for weeding in row crops. The wheel hoe is operated by one person. However, in heavier soils another person is required to pull the tool. As the hoe is pushed forward with the help of handles, loosening of the soil is accomplished. The depth of hoeing can be varied from 2.5 to 5 cm. Different types of working tools can be fixed depending upon row spacing and the type of job to be performed. The different type of blades include V-blade, scrapper blade, tines, rack, etc. An area of about 0.2 hectare can be covered with this tool in a day.

(iii) Peg Tooth Weeder

A peg tooth weeder (Figure 3.25) is suitable for weeding in row crops in rain-fed and garden lands. It can easily be operated by a man or woman. It can also be utilized in mulberry gardens provided that weeds are small and shallow rooted. About 0.1 to 0.2 hectares can be covered in a day with a peg tooth weeder .

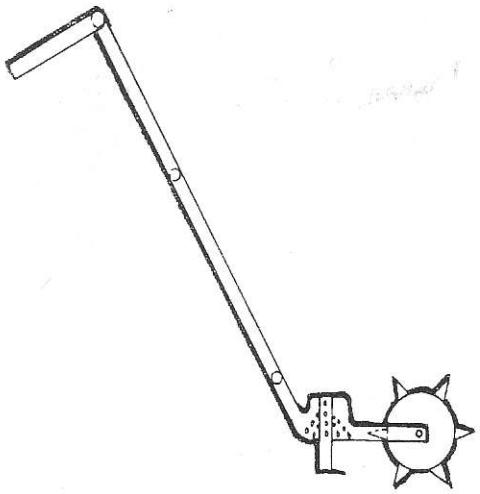


Figure 3.25 : A peg tooth weeder

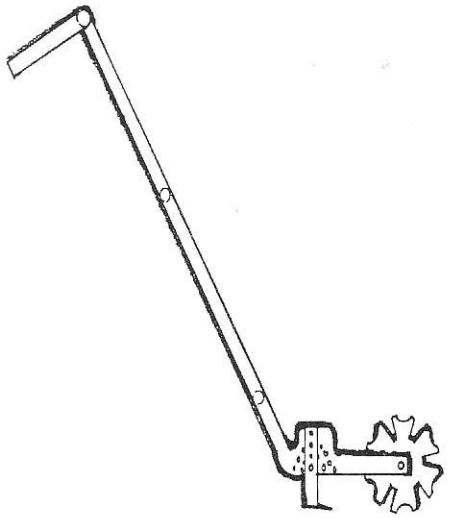


Figure 3.26 : A star weeder

(iv) Star Wheel Weeder

Star wheel weeder (Figure 3.26) is similar to peg tooth weeder except the star roller wheel facilitates easier operation of the weeder in loamy and sandy soils.

(b) Animal Drawn Weeders

Country plough or 3-5 tyne animal drawn cultivators are used for intercultural and weeding operations in a mulberry gardens.

(c) Power Tiller Drawn Weeders

The power tiller operated cultivator and rotavator could be used effectively for weed control in a mulberry garden. Figures 3.27 & 3.28 show the operation of cultivator and rotavator for weeding and intercultural operations in a mulberry garden. About 3.5 to 4 hours are required to cover one hectares of mulberry garden.

(d) Self-Propelled Weeders

Self-propelled weeders comprises of a built-in power unit, generally a petrol or diesel engine, as a part of weeder (Figure 3.29). The weeders are available in different width and capacity. The performance, reliability and economics of these have yet to be established for intercultural and weeding operations in mulberry garden.

(e) Tractor Drawn Weeders

Cultivators mounted with reversible shovels or sweeps could be utilised for weeding between the rows. These have already been described in detail in Section 3.2.3.d. Figure 3.30 shows the utilisation of a tractor operated cultivator for weed control and intercultural operations in a mulberry garden. A tractor operated cultivator can cover an area of 0.75 - 1 ha/hr.

Figure 3.27 : A power tiller operated cultivator in a mulberry garden

Figure 3.28 : A power tiller operated rotavator in a mulberry garden

Figure 3.29 : Different types of self-propelled weeders

Figure 3.30 : Intercultural operations in a mulberry garden by a tractor operated cultivator (a) 7 days after pruning (b) 25 days after pruning

3.5 MACHINES FOR APPLICATION OF CHEMICALS

Chemicals play an important role in sericulture. Various type of chemicals used in sericulture are :

1. Insecticides for control of insects and pests of mulberry plants
2. Insecticides for control of parasites of silkworm
3. Fungicides for control of mulberry and silkworm diseases
4. Herbicides for killing weeds in a mulberry garden
5. Hormones or growth regulators for accelerating mulberry growth
6. Plant nutrients to increase plant foliage
7. Disinfectants to create germ and diseases free environment for silkworms in a rearing house
8. Growth hormones for silkworms

3.5.1 Different Forms of Chemicals

Chemicals are generally applied in the form of powder, granules, liquids and gases.

(i) **Powder or dust :** The application of dust is easy but have drawbacks like high drift and low percentage of deposition. Some common chemicals in dust/powder form used in sericulture are : Resham Keet Oousadh (RKO), Vijetha, Powders A&B, Bleaching powder, BHC, Lime, etc.

(ii) **Granules :** The chemicals in form of granules such as Furadon or Forate, etc. are commonly used for soil treatment for control of weeds over a period of time. The chemicals in granular form have long effect when compared to chemical liquids and powders. Hence, the residual effects of chemicals in granular form are more and for long duration.

(iii) **Liquids :** Most of the chemicals used in sericulture are in liquid form for the reason that small quantities could be sprayed over a large area by dilution with water. The major advantages of using chemicals in liquid form are uniformity in application, deposition is high, liquids could be put exactly on target & soil pollution is less. Some common liquid chemicals used in sericulture are formalin for disinfection of rearing houses, uzicide for Uzi control, Rogor, DDVP (Nuvan) Dinocap, etc. for control of insects and diseases of mulberry, glycel - a herbicide, Vipul & Harith - growth regulators, Sampurna - for uniform silkworm maturity, Juvenile hormone - for extending silkworm larval duration, etc.

(iv) **Gases :** Chemicals in gaseous form are generally used for stored products for controlling attack of pests and diseases. The major advantages of using chemicals in gaseous form that large quantities could be treated in a short time, gases are used in closed chamber or container, hence pollution is less, application is easy and safe, residual effect is less and only for short duration. Use of chemicals in gaseous form is very limited in sericulture. The only known use of chemical vapours in sericulture is for checking attack of pests such as Dermestis beetles on cocoons in a store room and fumigation of rearing houses by formaldehyde.

3.5.2 Chemical Application Devices

The chemical application devices are broadly classified as :

(a) manually operated chemical applicators and

(b) power operated chemical applicators

They are further classified on the basis of the form of chemical as :

(a) Dusters for application of dusts/powders

(b) Sprayers for applications of chemicals in liquid form

(c) Granule applicators for applications of chemicals in granular form

(e) Fumigators for treating materials with fumes of chemicals

3.5.2.1 Dusters

A duster consists of a container to store chemical powder through which air current at high velocity is passed. The air lifts the chemical particles and take them out through an orifice. The air current is created through an air bellow or a rotary fan. There are many type of dusters but the most popular is the rotary duster (Figure 3.31). It consists of a blower, transmission system and a hopper. The blower is driven by a hand operated crank and a set of gears to impart necessary speed. The air is blown over the chemical powder which comes out with air. These dusters are only suitable for application of dusts in mulberry garden on plants and soil but not or dusting chemicals over silkworms inside the rearing house. As per practice, the farmers dust bed disinfectants using a muslin cloth. The dust passes through openings of the cloth and falls uniformly on the silkworms. Bellow type hand dusters (Figure 3.32) are available in market but they could not get much popularity among farmers as dust is not applied uniformly over silkworms. To overcome the problem of dusting silkworms, a battery operated duster has been developed by CSRTI, Mysore and the same is described in Chapter 4. It applies dust uniformly and gently over the silkworms.

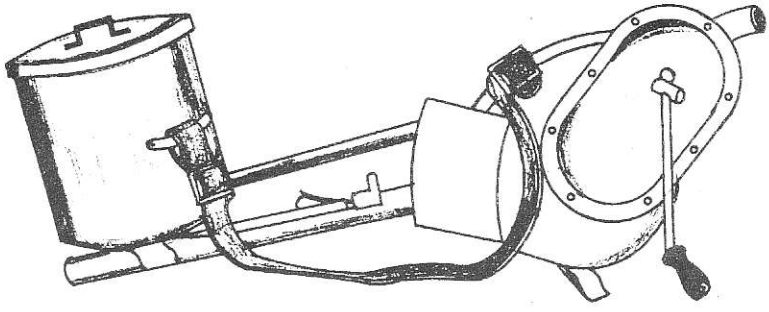
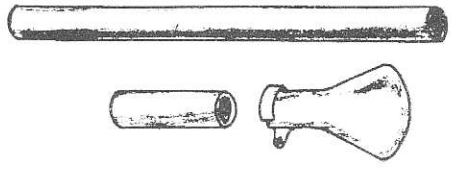


Figure 3.31 : A Rotary duster



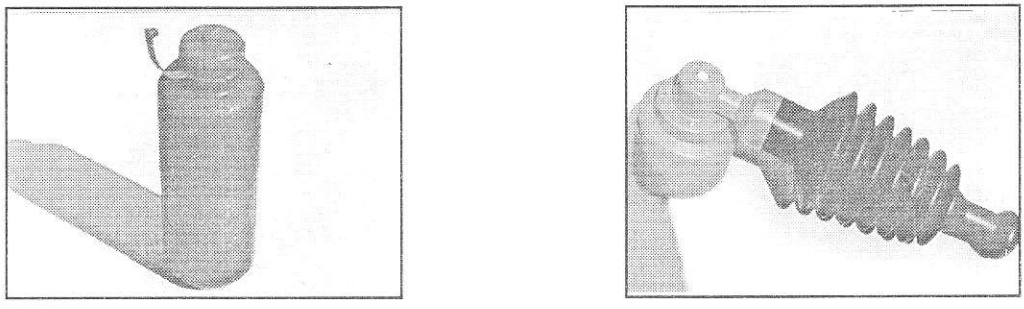


Figure 3.32 : Bellow type hand dusters

3.5.2.2 Sprayers

The main function of a sprayer is to break the liquid into droplets of effective size and distribute them uniformly over the surface to be treated or protected. Different type of sprayers, manually and power operated, are available in the market. All these have common features such as :

(a) a container for storing liquids or chemical

(b) a feed system for liquids - pressure feed or gravity feed

(c) an atomising device (called commonly as nozzles)

Nozzles : Nozzle is a device through which liquid is emitted, broken up into fine droplets and dispersed over an area. Nozzles are classified according to energy utilized to break up the liquid into droplets , namely hydraulic, pneumatic and centrifugal.

Hydraulic Energy Nozzles : In this type of nozzles, liquid under pressure is forced to pass through a small opening or an orifice to impart sufficient kinetic energy to push out the liquid, usually in form of a thin sheet which becomes unstable and disintegrates into droplets of different sizes (Figure 3.33). Usually, 2-3 atmosphere pressure is required to provide sufficient velocity and energy for development of the spray pattern. Such nozzles break up the liquid into droplets ranging from 150 to 400 microns.

Different types of hydraulic nozzles are :

(a) Jet or solid stream nozzles

(b) Impact nozzles

(c) Flat fan nozzles

(d) Cone or swill nozzle

- Hollow cone
- Solid cone

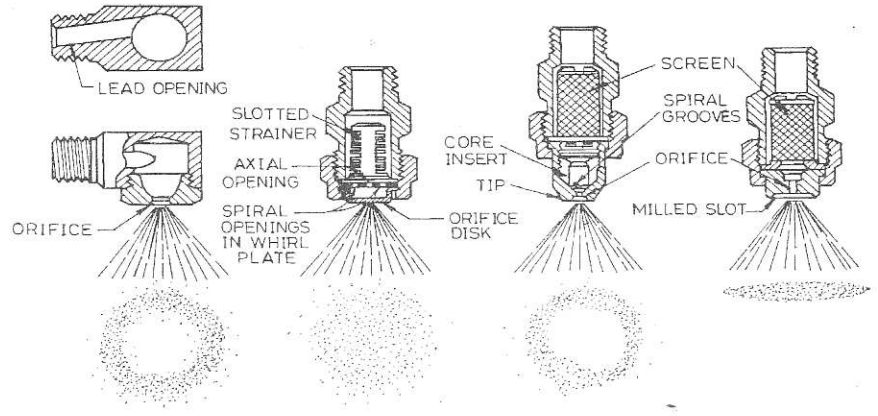


Figure 3.33 : Different type of spraying patterns

Pneumatic Nozzles : Disintegration of liquids into droplets can be achieved through impact of one fluid (say pesticide) with another fluid, usually an air stream. One of the simplest types of such device is domestic flit gun (Figure 3.34). A stream of air stream at high speed breaks the chemical into fine droplets.

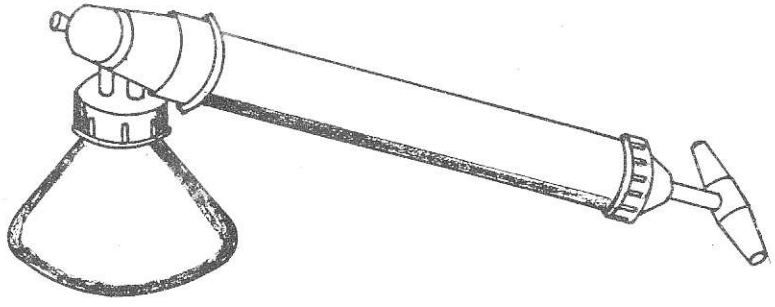


Figure 3.34 : A pneumatic sprayer

Centrifugal Energy Nozzles : These nozzles, also termed as spinning disc or rotary nozzles (atomisers), are used mostly for producing very fine sprays and mists (Figure 3.35). Liquid is fed near the centre of a rotating disc so that the centrifugal force takes the liquid to the edge. The liquid leaves the edge of edge in form of droplets. The size of droplets depends upon the speed and diameter of disc. The main advantage of a centrifugal energy nozzle is that chemical could be applied directly without dilution thus increasing its effectiveness. In normal course, the chemical shall be diluted to minimum 250 litres of water to cover one hectare whereas only 20-25 litres of water is required to cover one hectare when centrifugal type energy nozzle/sprayer is used. In dryland areas, this sprayer will have higher utility.

Figure 3.35 : An Ultralow volume battery operated sprayer

In sericulture, the following types of sprayers are most common :

(a) Hand operated knapsack sprayer

(b) Rocker sprayer

(c) Foot operated sprayer

(d) Compression sprayer

(e) Power operated knapsack sprayer

(f) Power operated sprayer (tractor, power tiller or engine operated)

(a) Hand Operated Knapsack Sprayer : The common type of a knapsack sprayer is provided with a pump and a large air chamber mounted in a 9 to 20 litres tank. It is carried on back by a worker. The handle of the pump extending over the shoulder or under the arm of the operator makes it possible to pump with one hand and spray with the other. A uniform pressure can be maintained by keeping the pump in operation. Figure 3.36 shows main parts of a knapsack sprayer. This sprayer is very useful for spraying small trees, shrubs and row crops. Knapsack sprayer has extensive use in mulberry cultivation for pest control and foliar spray of micronutrients and growth promoters. A worker can spray about half hectare in a day.

(b) Rocker Sprayer : It consists of a frame that holds the pump, handle and other accessories together (Figure 3.37). The suction and delivery valve are fitted in the pressure vessel. The strainer fitted to suction hose is put in the chemical solution. This sprayer develops high pressure and spraying takes palcewithout any pulsation due to provision of the compressed air in the vessel. This sprayer is largely used in sericulture for disinfection of silkworm rearing houses.

Figure 3.36 : Hand operated knapsack sprayer

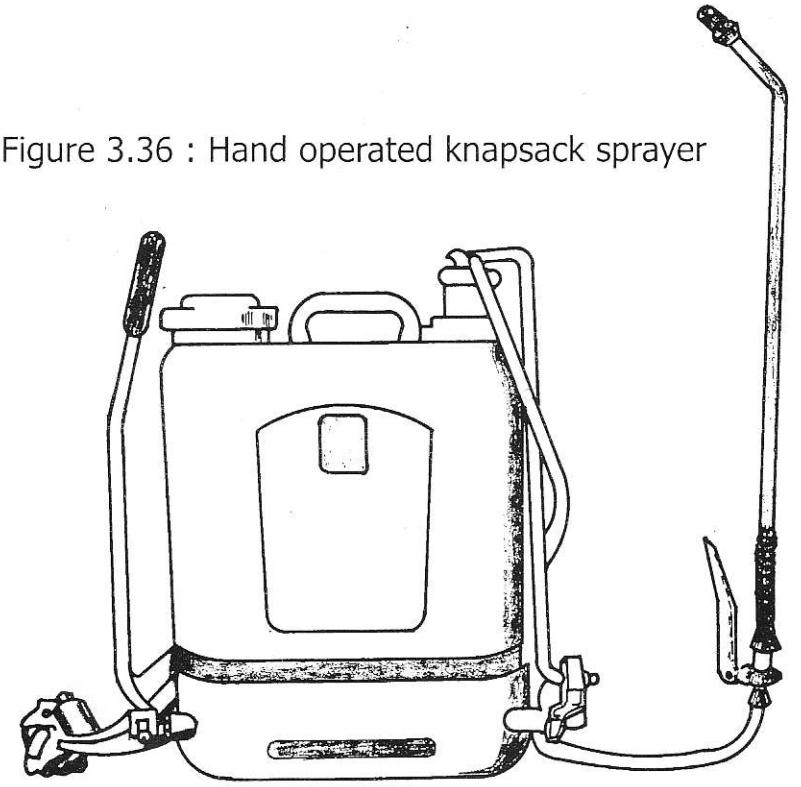
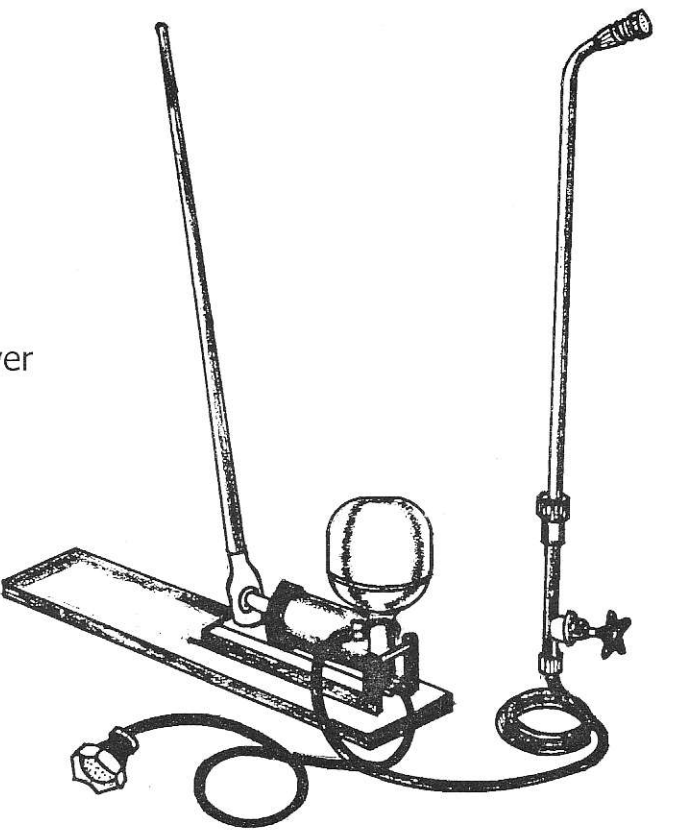


Figure 3.37 : Rocker sprayer



(c) Foot Operated Sprayer : This sprayer is highly useful for effective and economic spraying weedicides, pesticides and insecticides. The components of a foot operated sprayer are shown in Figure 3.38. It consists of a pump cylinder and a pressure chamber made of brass while stand is made of mild steel. This sprayer has uniform spray of the chemical. To operate this sprayer, two person are required, one for operating the pump and other for spraying the chemical. This sprayer is also used in sericulture for spraying disinfectants inside the rearing house.

(d) Compression sprayer : Figure 3.39 shows a compression sprayer. The spraying of liquid in this sprayer is achieved by pressurising the partially filled tank. The air is pumped into the top of the chamber and chemical sprayed until pressure becomes too low for good spraying. Frequent pumping is required to maintain the pressure. It requires one man for operation and can cover 0.4 hectares in a day.

(e) Power Operated Knapsack Sprayer : Figure 3.40 shows a knapsack power operated sprayer. It consists of a container with two chambers, one for chemical and other for petrol. A blower is mounted directly on the crankshaft of a high speed 2-stroke petrol engine of 1.5 to 3 hp. The chemical from container is mixed with air from blower. The air at high speed breaks the liquid chemical into fine droplets.

(f) Power Operated Sprayer : Figure 3.41 shows a power operated sprayer. It consists of a plunger pump and spraying devices. This type of the sprayers develop very high pressure and chemical can be sprayed over a distance of 8 to 10 meters. Power sprayers are getting popularity for disinfection in the silkworm rearing houses.

(g) CSRTI Self-propelled Boom Sprayer : A self propelled boom sprayer developed by CSRTI, Mysore (Figure 3.42a) suits well to paired row plantation. Two pairs i.e. four rows of the mulberry plants can spray in one pass. About one hour is required to spray chemical in one hectare (25 minutes/acre). This sprayer can also be used for disinfection of silkworm rearing houses.

(h) Power tiller operated Boom sprayer : Power tiller is a versatile prime mover in agriculture. The power tiller operated boom sprayer (Figure 3.42b) can spray the chemicals uniformly on the mulberry plants. The seat on the sprayers facilitates the operator to work with lease and less fatigue. About five hours are required to spray chemical in one hectare (2hr/acre)

(i) Tractor mounted sprayer : The tractor mounted sprayer (Figure 3.42c) can cover one hectare mulberry garden in just about 20 minutes. It can carry 400 litres of chemicals in the tank. 4 pairs i.e. 8 rows of the mulberry can be covered in a single pass. It suits well for large mulberry gardens. The tractor mounted sprayers can also be used for disinfection in the silkworm rearing houses by taking connection from pump of the sprayer. The tractor operated sprayers have to yet gain popularity in Indian sericulture.

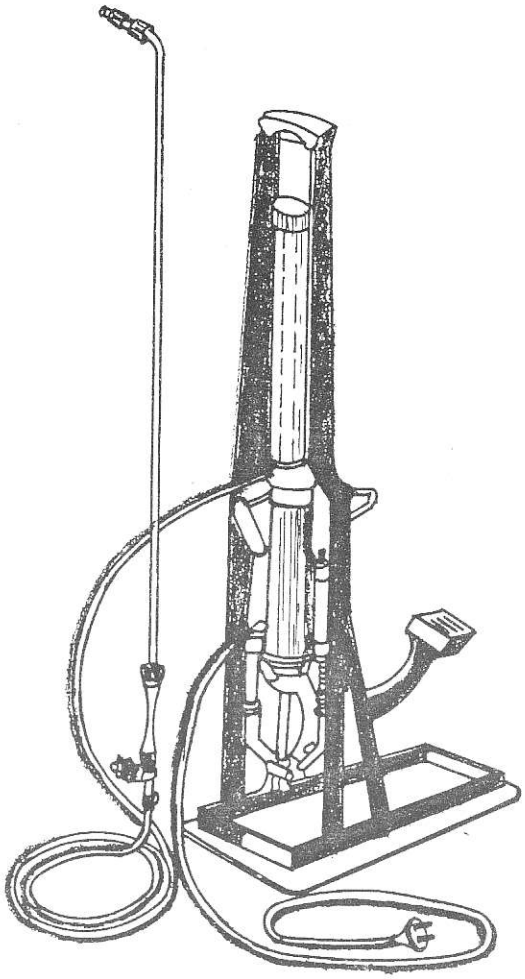


Figure 3.38 : Foot operated sprayer

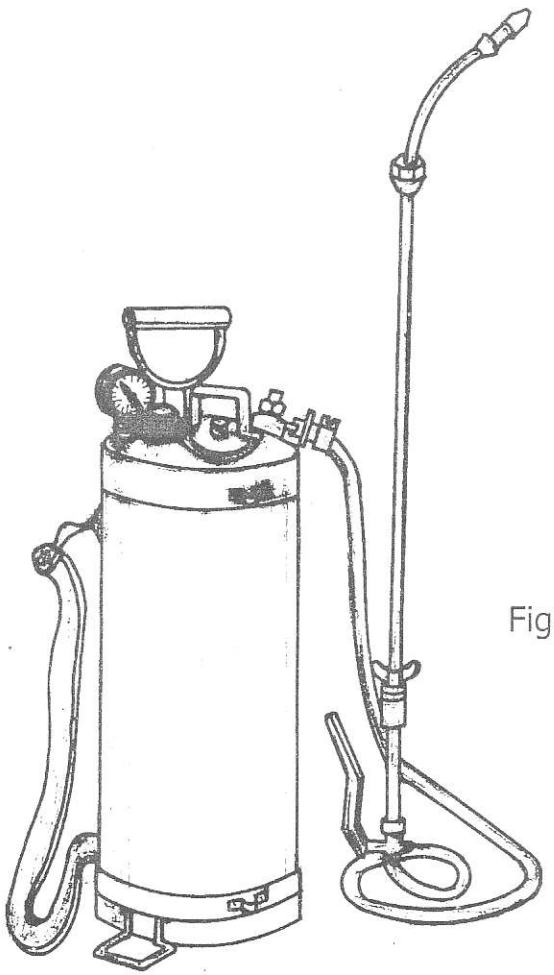


Figure 3.39 : Compression sprayer

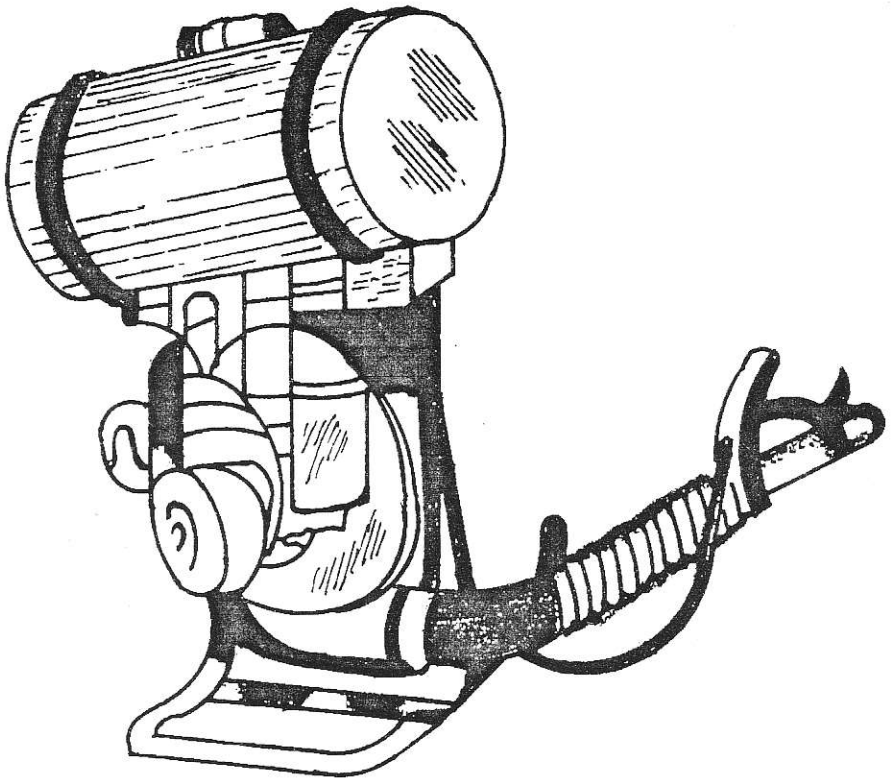


Figure 3.40 : Power operated knapsack sprayer

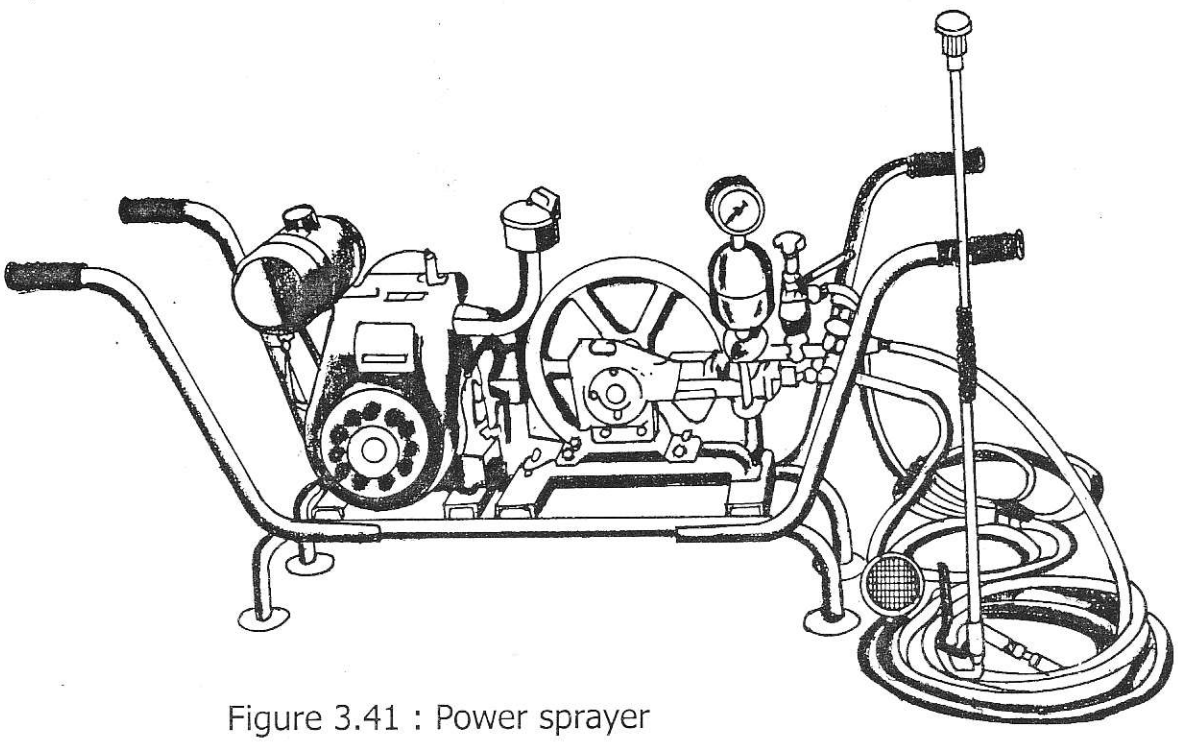


Figure 3.41 : Power sprayer

(a)

(b)

(c)

Figure 3.42 : (a) Self Propelled sprayer (b) Power tiller mounted sprayer (c) Tractor mounted sprayer

Chapter 4

SPECIAL PURPOSE MACHINES FOR SERICULTURE

In Chapter 3, different type of agricultural tools and equipments and their application for mulberry cultivation are described. In this chapter, machine for preparation of cuttings, mulberry shoot harvester, shoot crushing machine for production of compost, dusters for bed disinfectant application, flame gun, leaf chopper, machine for deflossing of cocoons and other machines developed specifically for sericulture by CSR&TI, Mysore are described.

4.1 MULBERRY CUTTING PREPARATION MACHINE

Mulberry is propagated vegetatively or through seeds. Vegetative propagation is common in India as it has distinct advantages like speedy multiplication of parent materials and maintenance of the desired characteristics of a variety. The vegetative propagation of mulberry involves preparation of nursery bed, preparation and plantation of cuttings, irrigation, weeding, uprooting, etc. As per present practice, the mulberry cuttings are prepared from selected 6-8 months old shoots having active and healthy buds. The shoots are cut into 22 to 25 cm long pieces manually using a sharp knife (Figure 4.1a). Each cutting should contain atleast 3 to 4 healthy buds. The upper end of the cutting should be cut straight whereas lower end should be cut an angle, preferably at 45 degrees.

Preparation of cuttings is a skilled job and has to be carried out by experienced workers. An experienced worker can prepare 1500 to 2000 cuttings in a day. The preparation of cuttings is a tedious and monotonous job as the workers have to sit continuously and work in one posture for long time. It has been observed that elderly workers are selected for preparing cuttings as they not possess the skill of doing the work but also have patience to prepare cuttings properly.

In manual preparation, it has been observed that a good number of cuttings are damaged due to peeling-off and crushing of the bark while cutting. A worker cuts cleanly during morning hours and with the progress of the day the sharpness in cutting reduces considerably. This results in loss of planting material which is generally procured at a high cost and with great efforts. It is also observed that delay in cuttings preparation and plantation reduces chance of survival. In certain varieties of mulberry, the survival percentage decreases considerably if preparation of cuttings and their plantation is delayed beyond 3-4 days after pruning.

To avoid delay and inconvenience caused in preparation of cuttings, a cutting preparation machine designed and developed by CSRTI, Mysore can be used.

(a)

(b)

(c)

Figure 4.1 :
(a) Manual preparation of cuttings
(b) Cutting preparation with machine
(c) Cutting prepared by the machine

4.1.1 Details of Cutting Prèparation Machine

The machine is quite simple from design and fabrication point of view. It consists of a toothed circular blade rotating at a very high speed. Power is supplied to the blade from a 0.75KW single phase AC motor and given required speed through a transmission system. Figure 4.2b shows a motorised cutting preparation machine in operation.

4.1.2 Operation of Machine

The machine can be operated by a skilled worker. Prior to cutting work, the healthy and matured shoots with active buds are to be selected and dressed manually. Once, the shoots are ready, they are cut into pieces by rotating blade. The worker has to control the length, number of buds and angle of cut. Figure 4.1c shows a cutting prepared from machine. The operation of the machine is simple. A long run test showed that on an average 1,500 to 2,000 cuttings could be prepared per hour (12,000 to 16,000 per day of 8 working hours). The cutting rate, however, depends on the proficiency of the worker, quality of cutting material, age and diameter of shoots etc. The machine could be run continuously for 1-2 hours after which a break is required for cooling of belts, pulleys and motor. The machine on an average consumes 0.75 to 1 unit of electricity per hour.

4.2 MULBERRY SHOOT HARVESTING MACHINE

These days shoot rearing has become popular among farmers due to many distinct advantages. The mulberry shoots are harvested by farmers with help of various kinds of hand tools such as sickle, pruning saw, secateur, etc. (Figure 4.2a). About 40 mandays/ha/crop are required to harvest mulberry shoots. The harvesting efficiency is very low (0.025 ha/day) and the cost of harvesting is very high (Rs. 3,200/ha). Also from ergonomic point of view, the worker has to bend and work for a long time, which involves drudgery (Figure 4.2b). It has been noticed that as the existing pruning saws have single direction cutting teeth and it cannot cut the plant in forth and back directions. As the mulberry shoots are very hard and thick, the energy required for harvesting them is quite high. Manual pruning is economically justified and feasible for small gardens. For large scale cultivation of mulberry machines are required for harvesting shoots.

A power tiller operated shoot harvester developed by CSRTI, Mysore is a faster and cheaper means for harvesting mulberry shoots (Figure 4.2c). It suits well to paired row plantation. The machine advances at speed of 1 km/hr, harvests 30-35 plants/minutes or 40-45 kg shoots/minute (2400-3000 kg/hr). The cost of operation of machine is about Rs.150/hr. This machine is quite suitable for large scale mulberry cultivation.

(a) (c)

(b) (d) (e)

Figure 4.2 : (a) Different mulberry shoot harvesting tools (b) Manual shoot harvesting (c) Power tiller operated shoot harvester (d) Shoot harvester in operation (e) Plants after shoot harvesting

4.2.1 Description of Machine

The mulberry shoot harvester shown in Figures 4.2c is an attachment to a standard power tiller (make : Mitsubishi-Shakti). It comprises of a frame, drive mechanism, circular blade, support wheel, guide and guard.

Frame : A rigid frame comprising of iron angles, flats, channels has been provided to support the drive mechanism, circular blade, support wheel, guide and guard. The frame is rigidly mounted on the power tiller chassis with nuts and bolts.

Drive Mechanism : The drive mechanism comprises of shafts, bearing, V-grooved pulleys, belts and bevel gears for transmission from power tiller drive pulley to the circular blade.

Circular Blade : Circular stainless steel blades having 20, 30 and 45 cm diameter could be fixed on the machine for harvesting mulberry shoots. The diameter of blade to be fixed on machine depends upon the girth of plants. A special care has been taken for fixing the circular blade so that it does not fly-off from the machine during pruning operation. The blade has been fixed in such a way that it approaches mulberry plant at an angle of 15 degrees with respect to ground to give a clean and angular cut and also to avoid polishing of stem, pealing of bark and clogging of shoots under the machine. The speed of the blade depends upon the throttle setting of the power tiller. At idle tiller speed, the blade rotates at around 2000 rpm, 3200 rpm at half throttle and 4350 rpm at full throttle. The throttle should be raised to full to provide adequate power and speed to cut thick shoots.

Support Wheel : A swivelling type wheel provides easy manoeuvrability and balancing of the machine during operation. The support wheel also serves as a device for adjusting the pruning height. The wheel is mounted on the frame with the help of U-clamps which can be loosened to vary the height of support wheel so as to raise or lower the height of circular blade with respect to the ground.

Guide : A guide in the front of machine to pushes and directs the shoots towards the blade for easy cutting. The guide also bends the plants towards left hand side so that they fall only on one side for easy collection.

Guard : A guard provides cover for circular blade and avoids any danger to operator if blade breaks or it comes out of the machine during the operation. The guard is fitted with a thick wire mesh so that the operator can see the operation of blade during harvesting operation and control the forward movement of machine.

4.2.2 Operation of Machine

For harvesting the mulberry shoots, the machine should be fixed to the power tiller. Different pulleys and belts should be aligned for smooth operation. Thereafter, a circular blade of suitable size is be fixed. The machine is then taken to field and aligned in such a way that the centre of blade coincides with the centre of row of the plants. The machine cuts the mulberry shoots while advancing and lays them on one side. Figure 4.2d shows harvesting operation using machine and Figure 4.2e shows the mulberry plants after harvesting of the shoots. The machine can harvest mulberry shoots in gardens having a minimum row to row spacing of 90 cm (3 feet). The machine works well in paired row plantation. For turning of machine a minimum gap of 120 cm (4 feet) should be provided on sides. About 4 hours are required for harvesting one acre of mulberry garden (12-13 hours for one hectare).

4.3 Motorised Knapsack Mulberry Shoot harvester

In tea gardens, motorised knapsack pruners are used for cutting branches of the plants. These machines are also used for cutting bushes and clearing lands. The knap sack brush cutter or tea pruners have been found quite suitable for mulberry shoot harvesting. These machines consists of a sharp rotating circular blade powered by a knapsack type petrol engine (2-3 hp). The blade rotates at speed over 10000 rpm. Such machines are imported and cost over Rs. 25,000, today. A worker can harvest mulberry shoots at the rate of 15-20 plants (18-25 kg shoots) per minute or 800-1000 kg shoots/ hr. The machine cuts the shoots very neatly without damaging the plants.

Figure 4.3 : Knapsack type bush cutter/ pruner and mulberry shoot harvesting with it.

4.4 MACHINE FOR CRUSHING MULBERRY SHOOTS FOR MAKING COMPOST

Manuring plays a vital role in mulberry cultivation. Mulberry, which is cultivated for leaves for feeding silkworms, utilises a lot of soil nutrients to put forth foliage. To augment production and quality of leaves, it is very essential to replenish the soil through periodic application of organic manures and fertilisers. Sharp increase in prices of latter during past few years has marginalised the profits in sericulture. Further, continuous application of fertilisers degrades the soil. Thus, use of organic manures should be promoted for higher profit in sericulture.

Organic manures supply plant nutrients, improve texture and water holding capacity of soil and also accelerate microbial activities in it. Studies have shown that fertilisers are more effective and efficient in the presence of organic matter in the soil. It is recommended that organic manures for rain-fed and irrigated mulberry should be applied @ 10 and 20 tones/hectare/year respectively for good quality of leaves and to maintain desired texture and high fertility of soil.

Organic manures are basically of two types i.e. Farm yard manure (FYM) and Compost. FYM is prepared by collecting and decomposing animal dung and waste straw in open pits, whereas Compost is prepared from green plant material decomposed in air tight/open pits.

As mulberry requires higher amount of organic manure, preparation and use of compost should be promoted among sericulturists. Mulberry produces a large quantity of shoots which are quite suitable for making compost as they contain enough moisture and cellulose. In addition to shoots, a good amount of uneaten/left over leaves and silkworm litter are also available on a sericultural farm which can also be utilised along with shoots for making compost.

Since mulberry shoots are quite hard and fibrous, it takes long time to decompose them in original form. Hence, direct use of mulberry shoots should be avoided. Chances of attack by termites are also higher if whole shoots are used. However, decomposition period for mulberry shoots could be reduced significantly by preconditioning them before putting in compost pits. Preconditioning involves cutting and crushing of shoots into small pieces and is essential for arresting biological activities in shoots which helps in quick decomposition of plant material, developing cracks in shoots to facilitate attack of fungi and bacteria on cellulose, reduction in volume of plant material to accommodate large quantity of shoots in a pit and easy transportation of plant material to compost pit.

Thus, a machine has been designed and developed by CSRTI, Mysore, for cutting and crushing the shoots of mulberry and plant materials.

4.4.1 Description of Machine

Figure 4.4 shows a shoot crushing machine. The machine consists of stationary and rotating drums , frame, drive system and an electric motor. The stationary drum is made out of thick M.S. sheet. Its basic function is to provide support while cutting and crushing of shoots. A feeding chute is also mounted on the stationary drum. An outlet is provided in the bottom for crushed material to go out. The rotating drum is mounted on a steel shaft supported by ball bearings. On drum M.S. spikes are provided for cutting and crushing of shoots. M.S. angles on the drum create suction for pulling shoots inside and also produce a blast of air for pushing crushed material out of machine.The machine is driven by a 3.75 kW electric motor.

Figure 4.4 : Shoot Crushing machine in operation and heaps of crushed mulberry shoots for composting

4.4.2 Operation of Machine

Shoots are fed to machine via feeding chute. They are drawn in and crushed into pieces. For better crushing, shoots should be held firmly while feeding. Frequent cleaning of outlet is required as fibers and large pieces of shoots block the outflow of crushed material. The machine can be operated with ease. It cuts and crushes mulberry and other plant shoots into very small pieces. It can handle 800-1000 kg of mulberry shoots per hour. However, size of pieces cut and output of machine depend largely on the hardness of shoots, feeding rate, proficiency of the workers etc. Normally, a worker is required to operate the machine but presence of second one helps in quick supply of shoots, clearing of outlet and arrangement of crushed and uncrushed materials. The crushing machine consumes about 4-5 units of electricity per hour.

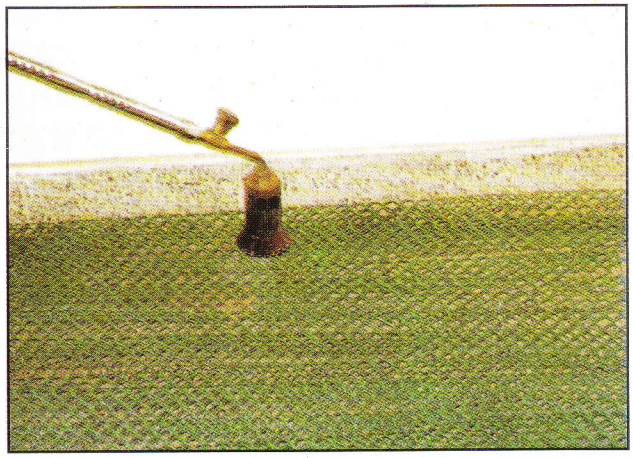
4.5 SERI TORCH

Fire is considered as best disinfectant. In sericulture Kerosene Blow Lamps are used extensively for disinfecting and cleaning bamboo mountages. A Seri Torch using LPG as fuel developed by CSRTI, Mysore could be utilised for disinfection of silkworm rearing houses and rearing equipments such as stands, mountages, etc.

The Seri Torch comprises of a LPG burner lance and a gas regulator. The length of the flame can be increased or decreased with regulator. A domestic or commercial gas cylinder can be utilised for flame gun. About one kg of LPG is utilised per hour thus making fire as cheapest disinfection method.

(a)

(c)



(b)

(d)

Figure 4.5 : (a) Seri Torch (b) Disinfection of stands with seritorch (c) Cleaning of floss from plastic mountages (d) Cleaning of floss from rotary cardboard mountages

4.6 MULBERRY LEAF CHOPPING MACHINE

The rearing of mulberry silkworms is fully domesticated. The silkworms during first two instars are fed with mulberry leaves cut into small pieces. In the later instar the silkworms are fed on whole leaves or mulberry shoots. The cutting of leaf into small pieces during 1st and 2nd instars is very much required as very small quantity of leaf has to be fed to large number of silkworms. As per the present practice, the mulberry leaves are cut manually into pieces with help of a sharp blade (Figure 4.6). Skilled workers cut the leaves. The leaves should be handled gently and there should not be crushing of leaves while cutting. The juice of leaves should not come out while cutting. The manual cutting of leaves is well suited to small farmers. For large scale rearing of silkworms and particularly for Commercial Chawki Rearing Centres (CRCs) a machine is required for cutting mulberry leaves at a faster rate as 200-300 kg of chopped leaves are required for each feeding.

Figure 4.6 : Manual cutting of mulberry leaf

CSRTI, Mysore has developed a hand operated-cum-motorised leaf chopping machine (Figure 4.7a). The machine can cut mulberry leaf into different sizes for different age silkworms (Figure 4.7b). About 225-250 kg of mulberry leaf can be cut in one hour. The machine is driven by ½ hp electric motor. The machine can also be operated manually in case of power failure. The machine is very useful for big farmers and especially for CRCs. The machine enables one to cut a large quantity of leaf with less effort.

Figure 4.7 : (a) A leaf chopping machine
(b) Different sizes of leaf cut by machine

4.7 POWDER DUSTER

Bed disinfectants like RKO, Vijetha, Ankush, etc. are applied over the silkworms emerging from moult to protect them from infection and diseases. As per present practice, the farmers keeps powder in a thin cloth and shake it over the silkworm uniformly (Figure 4.8a). Although, it is a simple method but not very hygienic as powder fly to hand and face of the workers. There is loss of powder also. Sometimes workers inhale the powder too. To overcome this problem, CSRTI, Mysore has developed a power operated duster (Figure 4.8b). The powder is filled in the duster. A mechanical vibrator provided in the duster shakes the wire mesh below the powder. The powder falls uniformly on the silkworms without flying. The duster saves loss of chemical powder and protects health of the workers.

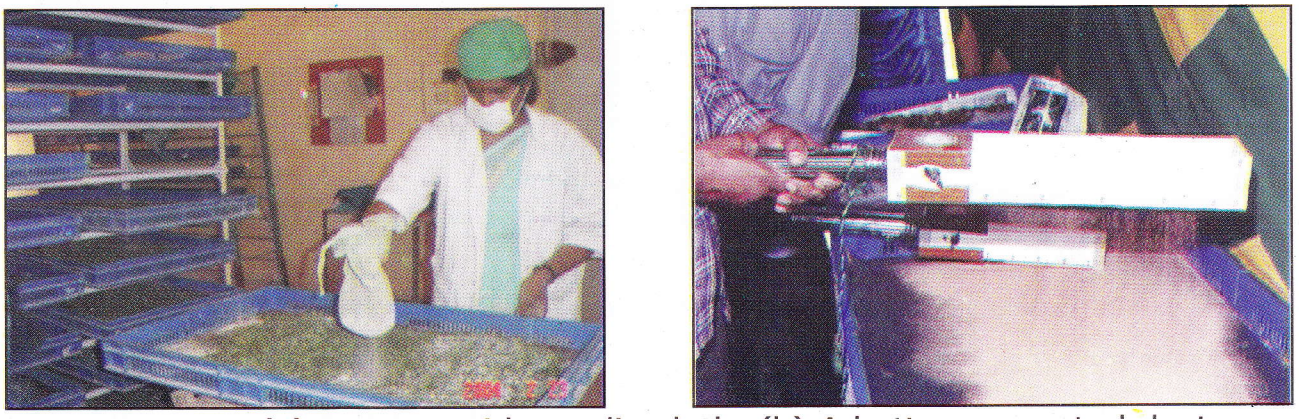


Figure 4.8 : (a) Dusting with muslin cloth (b) A battery operated duster

4.8 MATURED SILKWORM HARVESTER

When the silkworms are matured they are removed from rearing bed and kept in specially designed frames called mountages for spinning the cocoons. The timely picking of the matured silkworms is very important as any delay will make silkworms to start spinning the cocoon in the rearing bed itself. As per present practice in India, the matured silkworms are picked manually (Figure 4.9a) which is highly time consuming and feasible only for small rearers. About 3-4 workers are required for picking 100 dfl (45000-50000) larvae. Moreover, it is not possible to pick all silkworms from shoot rearing bed. The cocoons formed in the rearing bed are poor in quality, non-uniform in shape and size and fetch less price thus incurring loss to the farmers. To overcome the problem of picking matured silkworms, CSRTI, Mysore developed a machine for separating silkworms from mulberry shoots.

4.8.1 DESCRIPTION OF MACHINE

The matured silkworm harvesting machine comprises of a 180 cm x 120 cm (6 feet x 4 feet) vibrating bed powered by ½ hp electric motor. The frequency and amplitude of the vibrations given to the bed are 3.6 Hz and 12 cm, respectively. The vibrating bed is mounted on a metallic frame. The silkwors are collected on a platform below the vibrating bed. The machine consumes about ½ unit of electricity per hour.

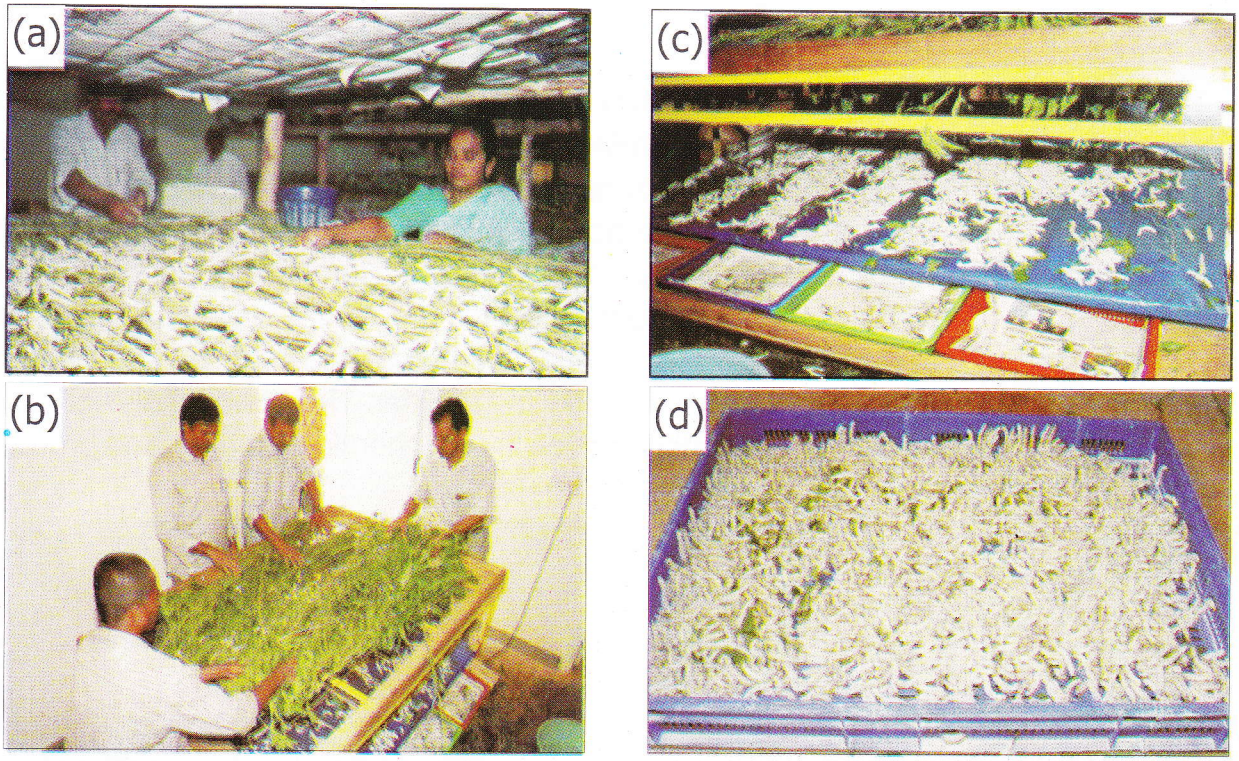


Figure 4.9 (a) Manual picking of the silkworms (b) a silkworm harvester in operation (c) silkworm collection board (d) silkworm collected from machine

4.8.2 OPERATION OF THE MACHINE

The operation of machine is very simple. When the silkworms start maturing or before last feeding, a nylon net with 12 mm x 12 mm (½" x ½") opening is placed on the rearing bed. The leaves and shoots should be placed over the nylon net. The silkworms crawl and go over the net for leaf. For separating the matured silkworms, the nylon net along with the leaf/shoots is taken to the machine and kept over the vibrating bed. The net is thereafter pulled out leaving leaf/shoots and silkworms on the vibrating bed. The machine is then switched on. Due to vibration given to the leaf/shoots, the silkworms are separated out and they fall on the collection board.

4.8.3 BENEFITS OF MACHINE

The benefits of the machine are :

1. Fast separation of the silkworms. This avoids spinning of the cocoons in the bed.
2. Almost 100 % silkworm are separated through machine thus no loss of cocoons, hence more yield.
3. Less cost for picking silkworms.
4. Beneficial to big rearers as machine facilitates quick picking of the silkworms.
5. The dependency on workers can be reduced and a farmers himself with his family members can separate the silkworms from rearing bed and mount them for cocooning.

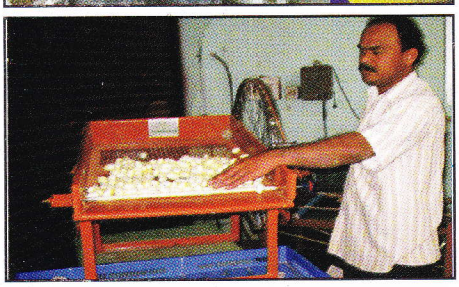
4.9 COCOON DEFLOSSING MACNINES

The reelable layer of the cocoons is covered by a soft and loose silky material called floss. It is essential to remove the floss from cocoons to find end of the filament. The floss also obstructs the free flow of cocoons in sorting and reeling machines. The process of removing floss from cocoons is called as deflossing or peeling of cocoons. In addition to deflossing of cocoons for reeling purposes, the cocoons for breeding and egg production should be deflossed for selection and assessment of their quality.

As per present practice in India, the cocoons are deflossed manually by reelers, researchers and egg producers. Deflossing cocoons manually is highly time consuming. On an average a worker can defloss around 3-4 Kg of cocoons per hour and 12-15 Kg in a day. The rate of deflossing of cocoons for research and breeding purpose is still slow. The manual deflossing although slow, care is given to individual cocoons and sorting could also be done simultaneously. In automatic and semi-automatic machines, deflossing facilities are available. In local reeling (charkhas) and reeling machines, the reeling cocoons are cooked in boiling water and floss is gathered through manual or mechanical brushes. It has been noticed that deflossed cocoons fetch higher price in market as in deflossed cocoons purchaser can observe the cocoon in better way and assess their quality and silk content more precisely. To assist reelers, researchers , egg producers and farmers, CSRTI, Mysore developed various kinds of deflossing machines.

(a)

(b)



(c)

(d)

(e)

Figure 4.10 : (a) Manual deflossing (b) Hand deflosser (c) Hand cum power operated deflosser (d) Power operated deflosser (e) Power operated high capacity deflosser

4.10 COCOON CUTTING MACHINE

In a grainage, the silkworm cocoons are cut manually for separation of male-female pupae for production of hybrid eggs. At present the cocoons are cut manually with a sharp razor or a safety blade which is a time consuming process. Some times, the person cut the finger with the blade. On an average, a worker can cut 300-400 cocoons per hour or 5-6 kg cocoons in a day. As a result a large number of workers are employed to cut the cocoons in a grainage thus increasing the cost of production. With introduction of Bivoltine races, the separation of the male-female at pupae level is a must for production of the eggs. CSRTI, Mysore has developed a motorised cocoon cutting machine which cuts over 5,000 cocoons per hour.

Figure 4.11 : Manual cutting of cocoons

Figure 4.12 : A cocoon cutting machine

4.11 TRAY WASHING MACHINE

In sericulture plastic trays are used for young age rearing, storage of cocoons and egg production. Before use of the trays, they must be washed thoroughly and disinfected . As per present practices, first the plastic trays are dipped in bleaching powder solution stored in a tank for some time and then cleaned and washed manually. This operation takes lot of time and causes delay. In young age silkworm rearing centres also called *CRCs* a large number of plastic trays are used. To facilitate washing and disinfection of plastic trays, CSRTI, Mysore developed a Tray washer. It comprises of a chemical storage tank, a pump, perforated pipes for spray of pressurised chemical solution on trays and nylon brushes for rubbing the tray sides and surfaces. Figure 4.11 shows a plastic tray washer under use. About 100-125 trays can be washed/hr.

Figure 4.13 : Plastic tray washing machine

ECONOMICS OF MECHANISATION

The ultimate aim of a farm activity is to produce different crops and earn life for the farmers. A farmer must generate adequate money and resources for his livelihood and sustain farm activity comfortably. He must have sufficient financial resources for future farm development works and add new activities. A farmer, therefore, must maximise the utilisation of his resources such as land, water, energy, machines, etc.

5.1 ECONOMIC PERFORMANCE OF MACHINES

For effective and efficient farm management, a farmer must know about the capacity of the machines, energy required for operation and cost of operation of the machines. Based on the farm size, capacity of the machines, initial investment to be made towards procurement of the machines, cost of operation of the machines, a farmer should decide whether it is beneficial to own or hire a machine. Many times other farmers may like to hire from machine owners. That time the machine owner should work out cost of providing machine on custom hiring.

The capacity of farm machines is expressed as area covered or crop material handed per unit time. The performance of most of the field machines such as plough, cultivators, sprayers, harvesters, etc. is reported as acres/hr or hectares/hr. Field machine performance is also called as theoretical machine capacity or field capacity [TFC] and could be determined as follows:

$$TFC = \frac{SW}{10} \quad (ha/hr)$$

Here S = Forward speed of machine in km/hr &
W = Width of machine in meters.

Reciprocal of TFC will give number of hours required to cover one hectare of area with a machine having working width of W and forward speed of S as defined above. During a farm operation with machine, a considerable amount of time is lost due to time required for machine preparation time at farm shed, travel time to and fro from field, turning time in field, time to attach or detach machines, machine adjustment, maintenance time (refuelling, lubrication, tightening etc.), repair time and operators personal time. On an average about 10-15% time is lost or less work is done. Hence, the Actual Field Capacity (AFC) is given below :

$$AFC = (0.85 \text{ to } 0.9) \times TFC$$

5.2 COSTS OF OPERATION OF MACHINES

One must operate farm machines at a minimum cost. The most of the management decisions for farm machinery involve an accurate knowledge of costs. The field machinery cost has to be worked out. The ultimate goal of a farmer or a machinery manager is to maximise the farm profits by getting the greatest output from his machines and keep cost of operation at the lowest.

5.2.1 Cost Determination

The cost of operation of a machine is divided into two categories, fixed cost and variable cost. The fixed cost is the expenditure made towards procurement cost of the machine, depreciation, interest on the machinery investment, taxes, housing and insurance. It is independent of use. Variable cost depends on the use of the machine. It includes the cost of fuel, lubrication, daily services and maintenance, power and wages for the operator.

5.2.1.1 Depreciation

Depreciation, often the largest cost of farm machinery, measures the amount by which the value of a machine decreases with the passage of time. The value of a machine declines as :

a. The parts of the machine wear out with use and cannot perform as effectively and precisely as the new parts. Sometimes it becomes uneconomical to repair some parts ; for example basic frame may be worn or distorted.

b. The expenses for operating the machine at its original performance decreases & more power, labour and repair costs for the same unit of output may be required.

c. The existing machine is said to be obsolete. The existing machine may be functionally adequate but a new, more efficient machine or practice available. When this situation develops because of new technology it is uneconomic to continue to operate it and hence the value of machine gets depreciated.

d. The size of the farm is changed and the existing machine capacity is not appropriate for the new situation.

It may be inferred from the above that depreciation is more likely a function of time for those machines having small annual use. Obsolescence and rust are most likely to end the life of machines. The life of machine ends mainly due to large use and mechanical deterioration.

The service life of a machine is needed to estimate depreciation. Service life in turn depends on the feasibility of repairing or replacing worn parts.

Depreciation methods

The depreciation of machine value depends mainly on the machine life. The Machine life for some common farm machines is as follows:

Tractors	12,000 hrs or 10 years
Tillage machines	2,500 hrs or 10 years
Harvesting machines	2,000 hrs or 8 years

a. Straight line method

If P = purchase price, S = salvage/junk value, and L = life of machine in years, the annual depreciation [D] is calculated as follows:

$D = (P-S)/L$

This method is the simplest, as it charges an easily calculated amount each year. This method is most commonly used for determination of depreciation of agricultural and farm equipments and machines.

b. Declining - Balance Method

A uniform rate is applied each year to the remaining value [includes salvage value] of the machine at the beginning of the year.

$D = Vn - Vn+1$

Where $Vn = P (1 - x/L)^{n}$ and $Vn+1 = P (1 - x/L)^{n+1}$

D = amount of depreciation for year n+1

n = the number representing the age of the machine in years at the beginning of the year in question

V = the remaining value at any time

x = the ratio of the depreciation rate used to that of the straight line method. x generally has value between 1 and 2 and commonly equals to 1.5

c. Sum -of-the-years-Digit method

The digits of the estimated number of years of life are added together. This sum is divided into the number of years of life remaining for the machine including the year in question. This fractional part of the difference between purchase price and the salvage value is the amount of depreciation charged every year.

$D = (L - n) x(P - S) / Yd$

Yd = the sum of years digits [1+2+3+.....L]

n = the age of the machine in years at the beginning of the year as declining balance method.

Example : Determine the fuel (diesel) consumption for a 35 hp tractor loaded half (for intercultural operations).

Diesel consumption for 40 % loading = 2.10 lits/hp/hr
Diesel consumption for 60 % loading = 2.40lits/hp/hr
Diesel consumption for 50 % loading = (2.10+2.40)/2 = 2.25 lits/hr/hp
Diesel consumption for tractor (50 % load) = (0.5x35)/2.25 = 7.8 lits/hr.

5.3 EXAMPLES OF CALCULATION OF COST OF OPERATIONS OF FARM PRIME-MOVERS AND MACHINES

5.3.1 COST OF OPERATION OF A FARM TRACTOR

Assume :
Cost of a tractor of 35 hp. = Rs. 3,00,000/- with accessories
Life of tractor = 10 years
Annual use of tractor = 1000 hours
Tractor load = 50 percent means only 17.5 hp utilised.

A - Fixed Costs

1.	Depreciation	: Rs. (300000 - 30000)/10	=	Rs. 27000
2.	Interest @ 10 %	: Rs. 10/100 X 300000	=	Rs. 30000
3.	Insurance @ 1 %	: Rs. 1/100 x 300000	=	Rs. 3000
4.	Shelter @ 0.5 %	: Rs. 0.5/100 x 300000	=	Rs. 1500
		Total fixed costs/year	=	Rs. 61500

Fixed cost per hour = Rs. 61500/1000 = Rs. 61.50

B. Variable Costs

1.	Fuel costs Consumption @ 7.5 lit/hr Diesel rate Rs. 35/lit	: Rs. 7.5 x 35	=	Rs. 262.50
2.	Oil & lubrication Consumption @ 0.01 lit/hp/hr Rate of oil = Rs. 100/lit	: Rs. 0.01x35x100	=	Rs. 35.00
3.	Wages of operator @ Rs. 100/day for 8 hr/day	: Rs. 100/8	=	Rs. 12.50
4.	Repair & maintenance @ 5 % of price	: Rs. 5/100 x 300000/1000	=	Rs. 15.00

Total variable cost/hr = Rs. 325.00

Hence total cost of operation of tractor/hour = Fixed cost + variable cost
= Rs. 62 + Rs. 325 = Rs. 387.00
Establishment charges = 10 % of Rs.387 = Rs. 39
Hence, the cost of operation of a 35 hp tractor/hr = Rs. 387 + Rs. 39 = Rs. 426
say Rs. 425/hr

5.3.1.1 COST OF PLOUGHING LAND WITH A TRACTOR OPERATED DISC PLOW

Working width of the disc plough (W) = 70 cm or 0.70 m
Forward speed of tractor during ploughing = 4 km/hr
Cost of a two disc plough = Rs. 15000/-
Annual use of disc plough = 150 hr
Life of a plough = 10 years

Cost of operation of plough

(a) Depreciation = (15000 - 1500) /10 = Rs. 1350.00
(b) Interest @ 10 % = 0.1 x 15000 = Rs. 150.00

Total cost per hour = (Rs.1350+Rs. 150)/150 = Rs. 10/hr

Hence, the cost of operation of a tractor operated disc plough per hour without establishment charges = Cost of operation of tractor per hour + Cost of operation of plough per hour = Rs. 425 + Rs. 10 = Rs. 435/hr

Area covered by plough in one hour, taking Actual Field Capacity as 80 %.

= 0.8 x S x W / 10
= 0.8 x 4 x 0.7 / 10
= 0.224 ha.

The time required to cover one hectare = 1/0.224 = 4.5 hr
Therefore, the cost of ploughing one hectare of land with a tractor operated disc plough = Rs. 435 x 4.5 = Rs. 1957.5 say Rs. 2000

5.3.1.2 COST OF INTERCULTURAL OPERATIONS WITH A TRACTOR OPERATED CULTIVATOR

Working width of the cultivator (W) = 250 cm or 2.50 m
Forward speed of tractor during intercultural operations = 5 km/hr
Cost of a cultivator = Rs. 15000/-
Annual use of cultivator = 300 hr
Life of a cultivator = 10 years

Cost of operation of cultivator
(a) Depreciation = (15000 - 1500) /10 = Rs. 1350.00
(b) Interest @ 10 % = 0.1 x 15000 = Rs. 150.00
Total cost/ hr = (Rs. 1350 + Rs. 150)/300 = Rs. 5/hr

Hence, the cost of operation of a tractor operated cultivator per hour without establishment charges = Cost of operation of tractor per hour + Cost of operation of cultivator per hour = Rs. 425 + Rs. 5 = Rs. 430/hr

Area covered by a tractor operated cultivator in one hour
= 0.8 x S x W / 10 = 0.8 x 5 x 2.5 / 10 = 1.00 ha.

The time required to cover one hectare = 1/1 = 1 hr

Therefore, the cost of intercultural operations in one hectare of land with a tractor operated cultivator = Rs. 430 x 1.00 = Rs. 430

5.3.2 COST OF OPERATION OF A POWER TILLER

Cost of power tiller with equipments= Rs. 100000

Life of a power tiller = 10 years

Annual use of power tiller = 800 hours

A. Fixed cost of operation per hour

(a) Depreciation = (100000 - 10000)/(10 x 800) = Rs. 11.25

(b) Interest on investment @ 10 % = 0.1 x 100000/800 = Rs. 12.50

(c) Housing/shed @ 2% of cost of power tiller = 0.02 x 100000/800 = Rs. 2.50

Total fixed cost per hour = Rs. 26.25

B. Variable Cost of operation per hour

(a) Fuel charges (0.20 x power in KW) X cost of fuel per litre = 0.20 x 7.5 x 35 = Rs. 52.50

(b) Lubrication oil @ 1 % of fuel cost = Rs. 5.25

(c) Repair & maintenance charges @ 10 % of original cost per year = 0.10 x 100000/800 = Rs. 12.50

(d) Operator wages @ Rs. 100/day (6 hr/day) = Rs. 16.60

Total variable cost per hour = Rs. 86.85

Hence, fixed cost + Variable cost = Rs. 26.25 + Rs. 86.85 = Rs. 113.10/hr

Establishment charges @ 10 of above = 0.10 x 113.10 = Rs. 11.30/hr

Therefore, the total cost of operation of a power tiller = Rs. 113.10+11.30 = Rs. 124.40 say Rs. 125/hr

Width of a power tiller equipment (W) = 70 cm or 0.70 m

Speed of power tiller during operation (S) = 3 km/hr

Hence, the area covered per hour = 0.80 x 3 x 0.70 / 10= 0.168 ha/hr

The number of hours required to cover one hectare area = 1 / 0.168 = 6 hr.

Therefore, the cost of covering or carrying out intercultural operations/ha = Rs. 125 x 6 = Rs. 750

Cost of intercultural operations/acre = Rs. 750/2.5 = Rs. 300

Addresses of Tools and Machinery Manufacturers and Suppliers

1)	**Ramkumar Industries,** P.Box No. 5309, Mettupalayam road, Vellaikinar Bus stop, Coimbatore- 6410 029	Tractor drawn agricultural implements	**0422- 2842056** **2842301**
2)	**Shiva Industries,** Mandipet, Tumkur- 572 101	Tractor drawn deep trencher	**0816-2278436** **2273450**
3)	**Farm Implements (India) Pvt. LtD.,** 17-19, NRN Colony, Thirumangalam road, Villivakkam, Chennai-600 049.	Tractor drawn Agricultural Implements	**044 -2619051**
4)	**JNP Agro Systems Pvt. LtD.,** 15, Poes road, 3rd street, TeynampetChennai- 600 018	Tractor drawn Rotovator and Trencher	**044-24347885**
5)	**M/s. B.N Auto Services,** No. 922, Kanthraja Urs road,Laksmipuram, Mysore - 570 004	Agricultural equipments	**082-2323157**
6)	**Bhagawati Enterprises,** G-11-12, Anand plaza, Nr. Ayad Bridge, University road, Udaipur- 313 001	Animal drawn iron ploughs	**0294-2429524** **2410813** **9414352746**
7)	**Popular Steel Works and Agrl. Implements Pvt. LtD,** Shivagi Udyamanagara, Kollapura-416 008	All types of tractor drawn and bullock drawn Implements	**0231-2657424** **2657376** **2657988**
8)	**Varsha Agencies,** Basaveswara talkies road, Near Vasavi Mahal, Chitradurga - 577 501.	Tractor operated, implements, Multi purpose mini -tiller, Chaff cutter & Garden tools	**08194-2422721** **2424941** **9448062124** **9448131063**
9)	**Trident Dynamics LtD.,** 3/507, Bharathi nagar, K- Vadamadurai, Coimbatore- 641 017	Varun Power weeder and Shredder	**0422- 2843684**
10)	**Anusham Farm Machinery & Power Equipments Pvt. LtD.,** 232, Sathy Main road, (Opp. Court) Gobichettypalayam (PO), Erode, T.N	Power weeder	
11)	**Souza Sifang Agro Engineering Pvt. Ltd.,** #.91, Iconet Business Centre, Temple Road, Malleswaram, Bangalore-560 003	Sifang (Chinese)Power tillers & accessories	**080-23318620** **23312527**
12)	**Kumar Industries/ Everest Industries** # 122-B, Palani Main road S.V. Mills Post-642 128, Udumalpet. Coimbatore District	Tractor drawn agricultural implements	**04252-22438** **9843024339**
13)	**TAFE Acces LtD.,** 35, Nungambakkam High road, Chennai - 600 034	Tractor drawn agricultural implements	
14)	**Premier Power Equipments & Products Pvt. LtD** NO.14, poomagal first street, Ekkattuthanga, Chennai-600 097	Power weeders	**044-556733001** **22346533**
15)	**M/s. Reliable Agro Industries Supplies** Shop No. 9, Madhwesha Complex, Nazarbad Mysore- 570 010.	VST Power tiller and their accessories Power sprayer	**0821- 2443783**
16)	**Kiran Corporation,** 21-B. D. Devraj road Urs road Mysore - 570 001	Gas Flame gun and Safety items	**0821- 2420889** **2430572**
17)	**Raj Enterprises,** 91-A, Belegola Industrial area, Metagalli, Mysore - 570 016	Motorised Deflossing Machine and Leaf chopping machine, Battery operated duster	**0821-2512856(o)** **2582656(W)**
18)	**Jayashree Dies and Components** 22/B, Revabhai Estate, Nr. Iswakrupa weigh-bridge, C.T.M, Ahmedabad-380 026	Horticultural hand tools	**079-5857821** **5857827** **9825329376** **9879352677**
19)	**M/S Balaji Agencies,** 153/1,Ramavilasa Road. K.R. Mohalla,Mysore-570 024	Electric sprayer	**0821-2428474**
20)	**S.V. Rangaswamy and Company.P. Ltd.,** No.2, 3rd Cross, Kalaysipalayam New Extension, P.Box. No. 6539, Bangalore - 560 002	All kind sprayers and hand tools like, Secateure, pruning saw	**080- 22222301** **22221778**
21)	**AQUA Services** No. 1256, Gaganchumbi Double Road, Kuvempunagar, Mysore- 570 023.	Garden care , equipments lawn mowers,agricultural sprayers and nozzles.	**0821- 2561155** **2567902**
22)	**Shah Spares & Services** Sri. Harsha Road, Mysore	Power Sprayer	**0821- 2434730** **2429083**
23)	**A.S. Industries,** # 49, 7th Cross, Rose garden, Off. Bazar street, Neelasandra, Bangalore- 560 047. Off/Works: # 14, 7th Cross, H. Siddiah road, Bangalore- 560 027	Agricultural Sprayers & Implements	**080-2237877080** **2234057080** **5717868080**
24)	**Jai Kisan Agro Equipments (P) Ltd..,** Plot No. 14 (I), Kolhar, Industrial area, Bidar- 585 403	Sprayers	**08482-232040** **232255**
25)	**Bhanumathy Agencies,** 37, Nehru street, Coimbatore-641 009	Sprayers	**0422-22345870** **2526653** **9843094587**
26)	**Indo German Plantation Machinery Co.Pvt. LtD.,** 22-A, I phase, Peenya Industrial Area Bangalore - 560058	Sprayers	**080-2395356** **2395357**
27)	**M/s. Ratnagiri Impex Pvt. LtD.,** Annapurna House, # 1/1G, 7th Cross, Mysore Road, Bangalore- 560026	Sprayers and Horticultural tools	**080- 26751658** **30610246** **30610162**
28)	**Vengateswara Agro Centre,** 93, Gokul Street, Ram nagar, Coimbatore- 641 009	Hand sprayers	**0422-2235389(o)** **2531846 (f)**
29)	**M/s. Bhuvana Enterprises & Kumaresh Agencies** 533-A, Nehru Street, Near kavitha theatre, Kasthuri Bhavan Hotel, I Floor, Ram nagar,Coimbatore- 641 009	Horticultural tools, secateurs, pruning saw, bill hook, different types of sprayers, weeding tools & equipments	**0422-231956** **233632**
30)	**Sumegha Agro equipments** 65, Kalingarayan street, Apsara theatre behind, Ramnagar, Coimbatore-641 009	Agricultural Sprayers	**0422-2231738** **9443046960**
31)	**Sri. Renuka Udyog,** MIG 1/20, Near KEC, Gandhinagara, Gokula road, Hubli	Agricultural Sprayers	**0836-2335228** **9448103583**
32)	**S.M. Power Products,** No. 52, R.V. Road, Near R.V. Teacher's College, Basavanagudi, Bangalore- 560 004	Power Sprayers	**080- 26572297** **26572298** **9845319549** **9880469628**
33)	**Orient Agro Engineers,** No.1 4th Cross, N.R. Road,Bangalore- 2	Power Sprayer	**080- 2233810** **2278676**
35)	**Spray Systems,** # 1/6, Jamia Complex, N.R. Road, Bangalore- 560 002	Agricultural Sprayers & Garden Tools	**080- 26704388**
36)	**Greaves LtD.,** Petrol Engine Unit, Thoraipakkam, Chennai-600 096	Knapsack Power Sprayers	**040-24925539** **6389**
37)	**Hi tech Agric Sprayer** F.No. 306 Pieco Aprt. 171, Balkampet rd.3, Ameerpet, Hyderabad-560 016.	All types of Agricultural sprayers	**040-23446048** **56991647** **9448149594**
38)	**The Kerala Agro Industries Corporation LtD.,** Kissan Jyothi, Fort, Thiruvananthaouram-695 023	Power tillers, Sprayers, Dusters and pump sets	**0471-2471343** **2471344** **2471345**
39)	**Supreet Electrical Industries** No. 58/2, Supreme Industrial Corporation Complex, Next to Bangalore International Public School, Chikkakallasandra, Subramanyapura Main Road, Bangalore - 560 061.	Circumferential room heater and humidifiers	**080-026669289** **98440 89097**
40)	**Green World Engineering** 51-A, Kasturibai Gandhinagar, Uppilipalayam Post, Coimbatore - 641 015	Tray washing machine	**0422-5547727** **2578597**
41)	**Dean, College of Agricultural Engineering & Technology** Tamilnadu Agricultural University Coimbatore - 641 003	Power tiller operated sprayer, auger diggers, hand operated mulberry cutting preparation machine, water pump, etc.	
42)	**Central Institute of Agricultural Engineering** Nabi Bagh, Berasia Road Bhopal	Various kinds of hand tools, power weeders, agricultural equipments	
43)	**CSRTI** Mannadavadi Road, Mysore 570008	Mulberry cutting preparation machine, Cocoon cutting machine, & Sericultural equipments and machines	**0821-2362406** **2901103**

Central Sericultural Research & Training Institute
Central Silk Board
Manandavadi Road, Srirampura
Mysore 570 008 (Karnataka), India
Tel . : 0821 236 2406, 2362440
Fax : 0821 236 2845