Technical Bulletin No. 22

BAMBOO PLANTATION

DR. RAM PRASAD

STATE FOREST RESEARCH INSTITUTE
JABALPUR (M. P.)

For Official Use Only

BAMBOO PLANTATION

Standardization of Techniques
for
Raising Nursery Stock, Plantations and Their After-care.

By
DR. RAM PRASAD
DIRECTOR
State Forest Research Institute
JABALPUR (M. P.)

CONTENTS

Bambusa arundinacea —

On favourable sites it grows well (one year old plant)

BAMBOO PLANTATIONS

Standardization of Techniques for Raising Nursery Stock, Plantations and Their After-care

1.0 INTRODUCTION

Though artifical regeneration of Bamboo had been attempted in the later half of the 19th centuary, yet it took almost one hundred years for it being taken up on large scale. Experience of Bamboo plantations using techniques such as seeding, planting of seedlings, rhizomes and cuttings etc., have been described by Dutta and Tomar (1964) in one of the Institute's publication. Since most of these older plantations were carried out on small scale, not much data are available about the suitability of a particular method. A brief review of the performance of some of the older plantations carried out in various forest divisions of Madhya Pradesh may provide some useful information to the practising foresters. Among a large number of species of Bamboos, **Dendrocalamus strictus** and **Bambusa arundinacea**, the two most commonly occurring species and which are of very high economic value, have been tried in different parts of this State. Based on research evidence and past experience, standardization of nursery and plantation techniques has been described in this bulletin.

2.0 PAST EXPERIENCE

Dendrocalamus strictus :

Sagar : Bamboo plants were planted along the Sonar river in 1873. Some plants were also planted along the perennial stream passing by the side of Forest Rest House, Ramna in 1874.

Three Bamboo nurseries, one each at Garhakota, Ranipura and Hathko were established. In all, 6,700 bamboo seedlings were planted over an area of about 38 hectares near Garhakota in 1879. The spacing of 4.5m x 4.5m was followed. Similarly, 3,315 plants were planted at Hathko also. Later on in 1906, a five year plan was drawn for restocking the open areas on Sagar hills by seed sowing. By this method, about 30 hectare area was covered. Early plantation of 1873 was harvested after about 8 years in 1881-82. However, the overall success of the bamboo plantations was not very good, as against about 250 hectares attemp-

ted by artificial regeneration, about 40 per cent area was written off as failure.

Damoh : One year old seedlings were planted in 1880 over an area of about 6 hectares in Kishantalao Reserve (near Damoh Station). These efforts, though on a small scale, continued till 1892-93. These plantations were found to be successful. In 1954, bamboo rhizomes were again tried in pits of 30 cm^3 at an espacement of about 8m x 8m over an area of about 10 hectares in Comptt. 209 of Singrampur Range. This plantation did not come up well on account of prolonged drought.

Jabalpur : Bamboo seeds were broadcast over a part of the Majhgaon Block in 1894. In a short period of 3 years (1897), 1.0-1.5m high plants were noticed in the area. Again in 1927-28, an area of about one hectare was planted using bamboo rhizomes in Block 11 of the then Murwara Range. In Barhi Range, 705 rhizomes were also planted but they all failed due to late planting.

Narsinghpur : In 1909, Bamboo seeds mixed with Khair **(Acacia catechu)** and Anjan **(Hardwickia binata)** were sown but without much success. Subsequently after 2 years, about 16,000 rhizomes were planted. These rhizomes sprouted well during the rainy season but thereafter, about 30-40 per cent plants were noticed dead.

Mandla : Seed broadcast was done in 1906 at different places in Banjar valley with a view to provide light overhead shade to the young Sal seedlings. In 1909, about 11,000 bamboo rhizomes were planted but most of them died during hot summer months.

Seoni : Stray attempts using rhizomes and direct seed sowing were made but no appreciable success is on record.

Chhindwara : Broadcast sowing of Bamboo was done over an area of about 200 hectares, considered as frosty locality. The seeds germinated well but fire swept the entire area and thus burnt down the young seedlings.

Bilaspur : Sowing of bamboo seeds in 1902, made in Dorki Reserve, failed except in one small area. However, broadcast sowing in teak plantations gave encouraging results. In 1947, about 400 rhizomes were planted on hill slopes facing Katra village but this did not meet with success.

Balaghat : Bamboo seedlings were planted at gully heads in anti-erosion working circle of Balaghat Forest School in 1940. The plants survi-

ved and grew in clumps in a period of about 10 years.

Khandwa : Early plantations using two years old seedlings were tried at Kirgaon and Atar in 1878-79. About 0.60 hectare area was sown with bamboo seeds. In 1879, about 200 hectares of area was planted with teak and bamboo mixture at a spacing of 6m x 10m. Most of the plants died on account of dry spell which followed after planting.

South Durg : In 1901, a small bamboo plantation using 120 rhizomes was raised. This effort did not give good results as 75 per cent of them did not establish.

South Raipur : Though two bamboo nurseries were established in 1922 yet there is no record of early plantation in this Division.

Bastar : In 1954, bamboo rhizomes were planted in clearfelled and burnt area but of the 6,000 rhizomes planted, only 2000 rhizomes were found established.

Gwalior : Bamboo has been tried as one of the species for ravine reclamation in Chambal areas. The bamboo seedlings were planted in first quarter of this century at Barhi near Bhind. Their growth was found to be poor.

Bambusa arundinacea (Katang Bans) :
This bamboo species was tried on a small scale in a few favourable localities of the State. In Balaghat, it was planted in Pandratola Block of North Balaghat Division between 1873-77. In a short period of about 7 years, the plantation started yielding marketable culms. The vigorous bamboo clumps of this species are still found in this area. **Bambusa arundinacea** was also tried in South Mandla and South Seoni Divisions between 1877 to 1890 but not much success could be achieved. Small scale plantations of this species were also raised in Chhindwara, Bilaspur, South Raipur and Sagar Divisions but all these efforts did not yield results comparable to those obtained in Pandratola Block of North Balaghat Division.

From the above experience, it is observed that various methods viz., direct seed sowing, planting of seedlings and offset or rhizome planting, have been used in raising Bamboo plantations. However, except in few cases, prolonged dry spell has been found responsible for the failure of plantations. Direct seed sowing and rhizome planting have invariably been found to fail unless there is sufficient moisture available to the plants. Seedlings have been found suitable provided care

is taken to allow seedlings develop proper size rhizomes.

Experiments to determine the circumstances under which the latent bud from the rhizome throws out an independent and vigorous shoot, indicated that while taking out seedlings, care must be taken to protect the rhizome buds. Research evidence indicates that the dug out rhizomes, when exposed to mild sun, give satisfactory survival. Mulching of one year old transplanted seedlings in November - December gave good results. It is experienced that smaller seedlings with under developed rhizome give poor results.

3.0 PREVALENT PRACTICES

The Bamboo nursery and plantation practices in various divisions of the State are not uniform. In some places, the seeds are sown in nursery beds in the months of August-September and when seedlings are 4-5 cm in height, they are pricked out in gussetted polythene bags of 25cm x 15cm size, and of 150 gauge. Next year by the commencement of the rains, they attain a height of about 50 cm and are planted out in pits of 45 cm^3 at a spacing of 4m x 4m. Thus, the nursery stock used for planting in the field in this case is about 8-9 months old. In other cases, when plantation targets are communicated at the tag end of the financial year, the seeds are procured from unknown sources. These seeds are normally of poor germination characteristics. The seeds are sown either directly in polythene bags or in nursery beds in late summer. These seedlings are pricked out in early June and are then planted in the field during rains in July. Sometimes, the plants attain a height of 30-50 cm in nursery beds by July and these seedlings are directly taken out for plantation in field. Since the rhizomes are of practically negligible size, the plants after rains do not survive. At some places, the rhizomes are extracted from natural forests and are transplanted in the polythene bags in April-May. The shoots are generally chopped-off before transplanting. The bamboo rhizomes in polythene bags send stout shoots, 50-60 cm high by July and these potted plants are subsequently planted in the field.

Sowing bamboo seeds in nursery beds and pricking out the seedlings in polythene bags are uniformly followed in most of the divisions with variation in the period between transplanting and actual planting. Direct sowing in polythene bags

with a view to reduce the cost in pricking process, has not been reported favourably. Gussetted type polythene bags are generally not insisted upon. There has also been substantial variation in the size of polythene bags. These variations range from 10 cm x 15 cm to 20 cm x 30 cm, mostly because the polythene bags of prescribed size are generally not available at the time of transplanting. Sometimes, the cost embargo in raising plantations compels the Foresters to reduce the size of bags.

Pit planting and spacing have also been quite variable from one forest division to other. At some places, smaller pit size of 30 cm^3 is adopted, mainly to economize the expenditure. At other places, the pits of 45 cm^3 are dug up. Normally, very little consideration is paid to the effect of the age of plants, size of polythene bags, rhizome development, pit size, soil working etc., on the survival and growth of plants in the field. Similarly, the impact of different espacements (4m x 4m, 5m x 5m and 6m x 6m) is generally not backed by research experience, as to what extent a particular spacing is responsible for the overall site productivity.

In view of the variability in practices and their uncertain results (survival and growth), there is a strong case to standardise nursery, plantation and tending techniques to ensure success and economise the cost of formation and maintenance of Bamboo plantations. To affect desirable economy, the following principles need to be followed :

(1) Reduction in nursery period by manipulating growth conditions and standardizing size of plantable seedlings.

(2) Reduction in nursery size to affect economy in labour charges.

(3) Creation of rhizome banks.

(4) Adoption of mechanical means at nursery and plantation stage, where feasible.

(5) General economy in individual operations, such as spacement of fence posts and number of strands in fencing, etc.

The standardizations, now laid down in this pamphlet, are to serve as guidelines for successful raising of bamboo plantations. Local modifications of minor nature, if found obligatory, may be adopted in consultation with the Director, State Forest Research Institute, Jabalpur, M. P.

4.0 STANDARDISED BAMBOO NURSERY AND PLANTATION PRACTICES

4.01 Bamboo species to be used :

Economically important bamboo species occurring naturally in the State are 'Bans' **(Dendrocalamus strictus)** and 'Katangbans' **(Bambusa arundinacea)**. Female bamboo **(Bambusa vulgaris)** is another favourite species grown by people in their homesteads, particularly in the eastern part of the State (Surguja, Bastar etc.)

Bambusa arundinacea is very exacting in its requirement for site, soil and sub-soil moisture, it flourishes only on deep alluvial soils along main streams. Such sites are extremely limited in extent and it is unlikely that extensive plantations of this species can ever be raised in the State. This is particularly so, because sites amenable for **Bambusa arundinacea** are also equally high quality sites for **Dendrocalamus strictus.** Accordingly no standardization is attempted for this species. **Bambusa vulgaris**, though extensively planted in homesteads by people, has not yet entered in forestry plantations. It has a great potential for raising plantations, because of its preference to flourish on heavy soils, attaining luxuriant growth, being not thorny and forming comparatively open clumps, which are easy to work. Experiments conducted by State Forest Research Institute have shown that unlike other bamboos, this species is capable of producing **Karlas** throughout the year under irrigated conditions. Where seed availability is a definite limitation, **Bambusa vulgaris** is preferable, as it can successfully be propagated by culm cuttings.

By far, the most economic bamboo species, which is presently planted extensively and is likely to be planted more so in future, is **Dendrocalamus strictus**. The standardizations of nursery, plantation and tending techniques of this species have, therefore, been given in this pamphlet.

4.02 Preparation of Plantation Project :

Project report for bamboo plantation should be drawn up at least one year in advance by a Forest Ranger. These reports should invariably be got inspected by Asstt. conservators of Forests and also by the Divisional Forest Officers. These reports would provide background information of the site and at the same time help the supervising and executing officials to make provisions for

various items, well in advance so that each operation is timely executed. Proforma for preparing plantation project has been given as Annexure 1.

4.03 Bamboo Seed Collection and Supplies :

The recognized method of raising plantations of **Dendrocalamus strictus** is to plant out sizeable nursery seedlings. Accordingly, an ensured supply of viable seeds is a pre-requisite for the continued plantation forestry of this species.

There are extensive (about 18,000 sq km in M.P. and 98,000 sq km in the Country) natural stands of **Dendrocalamus strictus**. Flowering and seeding, in one form or the other, are annual features. Sporadic flowering of individual clump is generally common everywhere, except in very moist localities. Gregarious flowering occurs only occasionally. It is likely that in due course, when bamboo plantations of various seed sources and forming a long age series, are extensively raised, gregarious flowering of this species may be predicted in various plantations with fair amount of accuracy. At that time, annual seed collection may be organized with greater certainty. Even if we look into the old records of various bamboo forests of the State, the phenomenon of gregarious flowering has been taking place at a definite interval of 35-40 years. The records collected from various forest divisions of the State are given in Table 1.

Table 1 : Past records of gregarious flowering of Bamboo in M. P.

Name of the Division	Year of gregarious flowering	Average flowering interval in years
1	2	3
Seoni	1921-23, 1939, 1962-65	20.5
South Seoni	1922-23, 1962-65	Seems to be partial
North Seoni	1962-64	—
North-Balaghat	1916-17, 1965-67	—
South-Balaghat	1916-17, 1963-64	—
South-Mandla	1899-1900, 1921, 1944-48, 1963-64	21
North-Mandla	1930-31, 1965-67	—

Name of the Division	Year of gregarious flowering	Average flowering interval in years
1	2	3
Jabalpur	1930-38 (partial), 1965 (partial), 1967-70 (partial) 1972-74	—
Bilaspur	1960-61	—
North-Bilaspur	1960-61	—
Sagar	1960-61, 1962-64, (1961-64)	—
North-Khandwa	1909-10, 1954-62	45
South-Khandwa	1909-10, 1954-56	45
North-Betul	1940-42 (partial in 1950), 1967-68	—
South-Betul	140-42 (partial in 1950), 1967-68 (Some ranges in 1950)	—
Hoshangabad	1948	—
Harda	1950-51, 1942-43, 1976-77	34
Raigarh	1945 (partial in 1954)	—
East-Raipur	1924, 1960-62	36
South Bastar	1948, 80-81, 1957-60	32
Dhar	1961	—
Rewa	1982	—
West Sidhi	1935	
East Kanker	1965-68	
Korea	1940	—
Jashpur	1960-63	—
Sheopur	No mention in the W.P.	—
Gwalior	No W.C. in the W.P.	—
Indore	No W.C. in the W.P.	—
Jhabua	No mention in the W.P.	—
East Sidhi	No record available as per W.P.	—
Dewas	No record as per W.P.	
Chhatarpur	No record available as per W.P.	—
Damoh	——do——	—
South-Raipur	No mention in the W.P.	—
Raisen	—do—	—
Shivpuri	—do—	—
Rajnandgaon	G. flowering not seen in the past as per W. Plan	—

Name of the Division	Year of gregarious flowering	Average flowering interval in years
1	2	3
East Chhindwara	No record as per W.P.	—
West Chhindwara	—do—	—
Narsinghpur	Sporadic flowering in 1981-82	—
North-Shahdol	Sporadic flowering has been common as per W.P.	—
North Surguja	Sporadic flowering was observed in 1959-60	—
West Bastar	Partial & sporadic flowering occurred during 1960-62 and 1976-78	—
Surguja	Sporadic flowering was observed in 1959-60	—

The following instructions would be useful for the field staff :

(1) All bamboo seeds produced in the State should, as far as possible, be collected fully and timely even if such a collection is not necessary for raising bamboo plantations in the State. Surplus collections can easily be disposed off at handsome price through Director, S F R I. The prevailing market price for good quality bamboo seeds (having a germination of 80 per cent and more) varies from Rs. 40-60/kg. In case of gregarious flowering, depending upon the extent of flowering and bamboo forests, on an average about 100-150 tonnes of bamboo seeds can be collected from each division and this quantity of bamboo seeds can easily provide an annual revenue of 40 to 60 lakhs of rupees. The experiment on seed production carried out in Barhi Range of Jabalpur Division and in Umaria Division of Shahdol District gave the following results (Table 2).

Tab'e 2 : Assessment of flowering and seed production

Name of Division	Location	Total no. of clumps per hectare	Mean no. of culms per clump	Mean periphery of clump (cm)	% clumps flowered	Average seed production per clump kg	Average seed production tonnes/ha
1. Umaria	Comptt-416	353	11.20	252.52	98.00	3.00	1.500
2. North Shahdol	Comptt-422	79	18.10	418.50	66.74	2.33	0.933
3. Jabalpur	Barhi Range	216	14.30	392.30	89.30	2.50	1.020

(2) Bamboo seed collection should be made with husk on. It helps in preserving viability of seed. This has been ascertained from experiments conducted on bamboo seeds of Shahdol, Umaria and Sidhi in 1985 (Table 3). Bamboo seeds collected with husk on from Shahdol gave a mean germination percentage of 91.00 as against 85.55 per cent without husk. In case of seeds from Umaria forests, the seeds with husk on gave the mean germination of 88.00 % against 80.00% in seeds without husk. Bamboo seeds from Sidhi Division also gave better germination per cent with husk on (84.66%) than the seeds without husk (77.00%). These results have been tabulated in Table 3.

(3) Sporadic flowering usually goes unnoticed and seed is mostly wasted. To ensure full collection of seed from sporadic flowering, the Divisional Forest Officers should obtain reports to this effect from Ranges during the first fortnight of December each year, and organise timely full collection of seeds. By early May, they should intimate the Director, S. F. R. I., Jabalpur as follows :

(a) No. of clumps flowered by individual Beats and Ranges.
(b) Quantity of seed collected.
(c) Quantity of seed required for local use
(d) Surplus quantity of seed available for transfer to SFRI, Jabalpur.

(4) Gregarious bamboo flowering in a locality spreads over a number of years and generally extends in the form of waves. As soon as gregarious bamboo flowering is noticed in any locality, the D. F. O. will immediately inform the Director, SFRI, with full details of observations and map of the area. Collection of seed from gregarious flowering will then be organised by concerned Divisional Forest Officers under the guidance from State Forest Research Institute, Jabalpur.

(5) Divisional Forest Officers having no or inadequate stock of bamboo seeds, should place their indents with the Director, S. F. R. I., and well in advance of the actual requirement.

Table 3 : Comparative germination capacity of husked and without-husk Bamboo seeds.

S.N.	Forest Division	Time of collection	Date of sowing	Comparative germination per cent	
				with husk	without husk
1.	Shahdol	March 1985	21.3.85	94.00	91.00
			17.4.85	95.00	93.00
			18.4.85	92.00	85.00
			22.4.85	88.00	81.00
			2.5.85	92.00	85.00
			14.5.85	82.00	76.00
			14.8.85	94.00	88.00
			Mean	91.00	85.55
2.	Umaria	March-April 1985	21.3.85	87.00	72.00
			18.4.85	89.00	88.00
			Mean	88.00	80.00

3.	Sidhi	March 1985	20.5.85	88.00	78.00
			9.7.85	75.00	71.00
			12.7.85	91.00	82.00
			Mean	84.66	77.00

(6) D.F.Os should not obtain bamboo seed supplies directly from outside the State. Bamboo seed from many dry localities produces only bushy clumps with switchy culms, which do not yield commercial bamboos.

4.04 Bamboo Seed Storage

About 30,000 bamboo seeds weigh a kilogram. Freshly collected seeds have a viability between 80 to 90 per cent. With passage of time, the viability decreases gradually. However, when the seeds are kept in air-tight containers and stored in cool places, the seed viability is enchanced. The experiments conducted on seeds stored in polythene bags gave germination of 75-80 per cent even after 9-10 months of collection. Bamboo seed should be collected with husk on, foreign matter removed carefully and thorcughly dried in sun. If such seed is properly stored, it keeps up viability for a maximum period of two years. Storage period may be prolonged under cold storage. Commercial cold storages are generally inoperative from about November to February each year. Accordingly, it is not possible to make use of this facility. It is desirable and economically feasible for the forest department to have its own cold storage for keeping the seeds of bamboo and other tree species known to have shorter viability period.

Bamboo seed is destroyed mainly by insects and rats. To ward off this damage, the following alternative may be tried :

(a) Seed should be stored in air-tight sealed drums kept in a cool place. To prevent insect damage, cotton soaked in E.D.C.T. (Ethyl di-chloride carbon tetra-chloride) may be placed inside. It is volatile and about ½ kg of this chemical is sufficient for about 4 quintals of seed. Sulphas tablets used in storing grains can also be used for this purpcse.

(b) Seed should be stored in gunny bags. The bags should be placed one over the other, after profusely dusting with 10 per cent B.H.C. or D.D.T. powder. The room should also be dusted and all outlets plugged to prevent entry of rats. There is comparatively more loss of viability when seeds are stored in gunny bags.

(c) Vacuum storage, if such facilities are locally available, may also be used.

4.05 Vegetative Propagation Material :

Culm-cuttings of **Dendrocalamus strictus** do not develop roots and shoots (except with certain hormones). They should not be tried.

Rhizome planting with a large culm portion, has occasionally proved successful. More often they fail completely. It is difficult to distinguish surviving but dormant rhizomes from the dead ones. In bamboo forests, where forest fires annually occur, the surface rhizomes are mostly dead. It is, therefore, suggested that rhizomes extracted from natural forests should not be used for plantation work.

4.10 BAMBOO NURSERIES :

Only permanant bamboo nursery (rhizome bank) should be maintained. Temporary nurseries, usually involve colossal wastage due to lax supervision, and should not be established.

4.11 Size of Nursery :

Creation of a nursery is in relation to the planting sites and its size precisely correlated with the number of seedlings which are expected annually from it, for planting out. Nurseries are, therefore, characterized by the number of seedlings which they are expected to produce annually, such as, 5-lakh nursery, 8-lakh nursery, 10-lakh nursery, etc. For the production of a specific number of seedlings, the size of a nursery can be precisely calculated, considering the space required for germination beds and storage beds to lodge polythene bagged plants. The space so calculated may be doubled for the nursery size, to accomodate for water channels, paths, nursery structure like shed for pump, seed and tool store, residential accomodation for nursery guard, labour shed, occasionally an inspection-hut etc., and space required for surplus seedling stock to carry over to the ensuing planting out season. Nursery space, in excess of this requirement, is not only wasteful but also involves expenditure of non-productive nature.

4.12 Number and Location of Nurseries :

For the assigned planting area of a range, the number of nurseries should be so decided that the targetted annual planting area is divided in such a manner that each sub-area lies within an economic radius from the individual proposed nurseries. For each nursery, therefore, definite areas by compartments or blocks should be assigned for annual planting. Thus, a minimum number of permanent nurseries for each range is fixed. If the planting area of a range is small, more than one range may be considered, at a time, for such planning.

4.13 Nursery Site :

Often the nursery site is selected in juxtaposition of headquarters of the subordinate staff. This invariably results in false economy because of the poor site for nursery. A permanent nursery site must conform to the following specifications :

(a) There must be a prerennial natural source of water. Alternatively, adequate water supply should be available from canals, tanks, tube-wells, ordinary wells, etc.

(b) The terrain should be flat or slightly sloping. On sloping ground, terraced beds along the contour are necessary to be made.

(c) Nursery soil should be alluvial to loamy and deep (not less than 60 cm in depth). There must not be large proportion of pebbles and stones. Heavy clay soils and light sandy soils should be avoided.

(d) There should be no salt accumulation in top soil.

(e) It must remain conveniently located for supply of seedlings to assigned plantation areas and for effective supervision by assigned staff.

4.14 Germination Beds :

The standard size of germination bed is 10m x 1.25m. In each nursery season, the germination bed will be dug up to a depth of 60 cm from the ground level. The dug out earth will be cleaned of roots and stones, and thoroughly mixed with adequate quantity of decayed farmyard manure and refilled in the bed in such a way that a sunken bed of 15 cm depth is formed. Raised beds with the provision of irrigation through side channels would facilitate proper development of root-shoot ratio. The latter-one has been experimented to provide better results.

4.15 Polythene Bags as Plant Containers :

Only potted seedlings of bamboo will be used

for planting out. Only polythene bags will be used as plant containers. The specifications for such polythene bags are as follows :

(a) The polythene sheet used will be of 150 gauge. Thinner sheets decay within a few months in the nursery and cause immense loss of seedlings. Gauge of the polythene sheet of bags received should be carefully determined and the fixed standard guaranteed. It is often risky to believe a commercial supplier for the prescribed gauge.

(b) No gussetted polythene bags will be used. They involve more cost without commensurate advantage. As the individual polythene bagged plants are not required to stand indefinitely in the nursery, gussetted polythene bags are of no advantage.

(c) The standardised polythene bag size is 9" x 6" (22.86 x 15.24 cm.), when flat. A much smaller size is equally advantageous, but manipulation by any reduction in size will await research results.

(d) Punch-holes for the intake of water and drainage are of no definite advantage. Polythene bags, without punch-holes, should be obtained. Prick-holes should be provided locally. For this purpose, 20 to 25 bags are taken together and prick-holes are made with a sharp nail. About 20 such pricks, within the lower 2/3 rds of the bag length, are sufficient.

4.16 Soil-Fill or Potting Mixture in Polythene Bags :

Potting mixture consists of soil and farmyard manure. The soil to be used, should be thoroughly dried up and beaten to a fine texture. All extraneous material of stones and roots should be removed by sieving. The farmyard manure to be

Table 4 : Proportion of various ingredients of potting mixture.

Nursery Soil		Imported Soil		Farmyard manure
Alluvial or Loamy Soil	3 :	Nil	:	1
Clayey Soil	3 :	Sand 1	:	1
Sandy Soil	3 :	Silt 1	:	1

used, should be thoroughly decayed and well dried up. It should also be beaten to a fine texture. Mixing of soil and farmyard manure should be very thorough and intimate. The proportions to be used are, as given in Table 4.

The polythene bags should be filled up with perfectly dry potting mixture. For quick filling of bags, a suitable sized scoop with hollow handle to pass the polythene bags, may be used. The hollow circular metallic portion should be inserted in polythene bags and the other end of scoop should be pressed in the stored potting mixture to allow fill the bags of soil mixture at ease. This saves time and money. It has been assessed that in comparison to hand filling, the use of light weight metallic scoop reduces time and expenditure by 60-75 per cent. Potting mixture should be thoroughly packed in each bag right upto the brim

Sowing in Germination Beds :

Sowings in germination beds should be done during September / October. Broadcast sowing is banned. Only drill sowing should be done. Drills should be 5 cm apart, and should run along the width of the bed. For making drills in germination beds, a frame, having strips 5 cm apart, may be used. It may be pressed lightly in worked-up and levelled soil of the bed. Seed with husk on is sown in drills. About one kg of such seed goes to a standard bed.

After sowing, the seed is covered lightly with fine soil. The thickness of this soil cover should not be more than twice the thickness of the de-husked seed. The entire bed is then lightly covered with straw and profusely watered with a fine rose can. Such a watering is continued, 2 to 3 times a day, till germination commences within about 10 days. Thereafter, watering is limited to twice a day. At each watering, care is necessary to ensure that there is no free accumulation of water in the bed. Similarly, bed is not over-saturated with water, so as to cause even incipient water-logging. When sufficient number of seeds have germinated and drill lines appear fairly stocked with young seedlings, the straw cover should be removed, and watering continued as before. Depending on the viability of bamboo seed used, 6,000 to 10,000 seedlings can be obtained from a standard germination bed.

Pricking-out in Polythene Bags :

The seedlings should be pricked out and transplanted in polythene bags, when they are

about 7 cm in height, in germination beds. The best results are achieved if pricking out is completed before November end. Pricked out seedlings should be watered and weeded regularly. NPK mixture may be given to seedlings when they are well-established in the bags. It is necessary to ensure that no incipient water-logging is caused within polythene bags and in beds where such bags are stored. They should always remain free from stagnating water.

The germination bed is thoroughly soaked with water before the pricking out operation commences. Similarly, polythene bags are profusely watered to make the entire soil-fill fully saturated with water. Bamboo splits are used in lifting seedlings from germination beds and transplanting in polythene bags. Only sizeable seedlings are pricked out and transplanted in polythene bags. The under-sized seedlings are left in the germination bed and watering is continued in usual manner till they grow to standard size for pricking out.

Often, the shoot of the pricked-out seedling dries up but soon new and vigorous shoots arise with the establishment of the seedling in the polythene bag. Each subsequent shoot is taller and thicker than the previous one.

4.17 Polythene Bag Storage Beds :

Standard size of polythene bag storage bed is 11 x 1.25m.

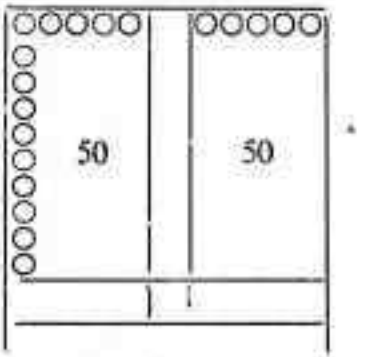
Depending on the availability of water and local convenience, the polythene bag storage beds may be of two types.

(A) **Surface Beds :** Four strong pegs are driven in the ground to define the four corners of the bed, and to these pegs, wire or thin bamboos are tied to define the limits of the bed and to provide support to polythene bags to be kept in the bed. Watering is done with rose-can, sprinkler or a rubber-tube connected with main water-pipe.

(B) **Sunken Beds :** Beds of 11.25 m x 1.50 m are marked on the ground, and are dug up to a depth of 40 cm. The entire bed is, then, lined with heavy clay soil to form the bed of standard size, i.e. 11 m x 1.25 m, and a depth of 15 cm. After storage of polythene bags in such beds, watering is done by flood irrigation. These beds are connected with each other and the layout of the sunken storage beds is such that the excess water of one bed passes on to the next bed, and

finally outside in the drainage channel. Clay-lining of the sunken storage beds maintains a moist surround and a humid atmosphere for a long period, thereby ameliorating growth conditions and cutting down the frequency of watering.

In the storage beds, sticks of 5 to 8 cm diameter are placed as per the design given below, to provide room for adequate growth. Instead of wood-pieces, mud-structures may also be used.



Accordingly, one standard storage bed will carry 1,000 polythene bags.

4.18 Direct Sowing in Polythene Bags :

Direct-sowing in polythene bags is a much safer and economical method of raising bamboo seedlings. This should be aimed as a final stage of development, and every effort should be made to popularise this practice amongst the staff. Once the confidence is gained, sowing in germination beds and pricking out in polythene bags will be abandoned.

Polythene bags should be neatly arranged in storage beds and profusely watered. In each bag, 3 seeds should be sown at 3 corners of a triangle of 2 to 3 cm sides, marked in the centre of the soil surface in the bag. The entire bed should be covered lightly with straw and watering done as prescribed for individual type of storage bed. As soon as germination is started and the majority of the bags in a bed are stocked with young seedlings, straw may be removed.

For direct-sowing in polythene bags, the sowing should be done in November. If there is possibility of applying doses of chemical fertilizers, such sowings may be delayed to even February.

If considered necessary, surplus seedlings in a polythene bag may be clipped after retaining the one which is best developed and is vigorous in growth.

4.19 Testing of Germinative Capacity of Available Bamboo Seed Lot :

Freshly collected bamboo seeds have a germinative capacity of over 80 per cent. With storage, this germinative capacity is lowered down, and depending on the type of seed storage adopted, the germinative capacity may range from about 60 to 70 per cent.

For direct-sowing in polythene bags, it is essential that the seed used is of a high germinative capacity. Alternatively it is preferable to sow seed in germination beds and prick seedlings in polythene bags.

Before launching mass sowings in nursery, it is desirable that test-sowings are made to determine germinative capacity of seed available in hand, and to manipulate rate of sowing in germination beds to avail full crop of seedlings for pricking out. Direct-sowing in polythene bags should be done only when the test-sowing indicates a germinative capacity of at least 60 per cent. Bamboo seeds, which are supplied by State Forest Research Institute, are tested and the germinative capacity of such seeds is generally more than 60 per cent. Accordingly, re-testing is not necessary.

4.20 Watering :

Where water-lifting is necessary, diesel or electrical pumps should be provided. Bringing of water from the lift-pump to the nursery should be through galvanised pipes of 5 to 8 cm diameter. Within the nursery, a water storage tank may be constructed at a commanding point from where water may be provided to the entire nursery through gravitational force. Galvanised pipes are not necessary for spreading water. They become necessary only with the sprinklers. Masonry channels should, generally, suffice. It is more preferable to have channels of clay and the outside of such channels be stocked with doob grass **(Cynodon dactylon)**. Where water resources are limited and flood irrigation of beds is not possible, sprinklers may be installed. Sprinklers are also advantageous in even spreading of water and creating a humid atmosphere for accelerated growth.

Germination beds should be watered with a fine rose-can. Two to three waterings may be done per day till the germination commences. Thereafter, only one to two waterings per day are enough. Regulation of watering at this stage is very essential. If watering is unduly delayed, the

plants retard in growth and may even die. Excess watering causes damping off.

Pricking out in polythene bags should be done only when the plants are thoroughly watered and no free water has accumulated in them. After pricking out, the bags should be watered once a day for 15 days by spraying. The pricked-out shoot generally dies but soon new shoots appear and continue to develop. This marks the establishment of the seedling in the polythene bag. The frequency of watering in storage beds, after the seedlings have established in polythene bags, should be as follows :

Surface Storage Beds	:	By spraying twice a day.
Sunken Storage Beds	:	By Flood Irrigation.
		Once in four days, during winter.
		Once in two days, during summer.

4.21 Shading :

Artificial shade is not required at any stage except straw cover on germination beds and directly-sown polythene bags till the germination commences.

Tall trees of Eucalyptus and Su-babul, widely spaced in the nursery, are advantageous. Trees of other species may also be retained but if their crowns are too large and thick with foliage, they should be heavily lopped before the nursery period starts in the annual cycle.

For proper growth of bamboo seedlings, maximum sunlight is necessary, once the seedlings are established in polythene bags. Water and nutrients should not be limiting factors. Under full sun, proper regulation of watering is essential.

4.22 Lifting of Polythene Bags and Changing Storage Beds :

This operation is generally carried out to prevent roots bursting through polythene bags and entering ground, and also to provide some sort of root-prunning to induce proliferation of liner roots. This is, however, not necessary for bamboo seedlings, and should generally be avoided. No definite advantage accrues to graminacious plants, and on the contrary, polythene bags are badly damaged to hold on the plant and to carry it to planting site. It may be resorted to only where it is absolutely essential due to local circumstances.

4.23 Use of Chemical Fertilizers in Nursery :

Whenever it is desirable to reduce the nursery period or to obtain plantable sized seedlings during a short period for planting out, resort should be made to provide profuse watering, coupled with ample sunlight and frequent doses of urea. About 2 per cent urea solution may be spread on seedlings, once they have established in polythene bags, and this dose may be repeated at a monthly interval, till possibility of having plantable-sized seedlings by planting-out date could be forecasted.

4.24 Use of Pesticides in Nursery :

In nurseries, where termite damage is feared, Thimet 10 G powder may be mixed in potting mixture of polythene bag at the rate of 5 to 10 gm/ per bag.

Damping-off and pathological wilting are common in Bamboo nursery. In damping off, while the entire shoot portion may appear healthy, pathogen attacks the collar zone and as a result, the shoots fall down. This is also called the foot-root. In Pahological wilting, the causative organisms may be **Fusarium, Macrophomina Cephalosporium** etc. The root portions are attacked in this disease and as a result, the entire plant dries up. Broad-spectrum fungicides such as 0.2 per cent Dithane M-45, 0.1 per cent Bavistein solution are used for soil Drenching. These fungicides should be used as preventive measures because once the plants are infected by these fungi, the revival through treatment is rather difficult.

4.30 RHIZOME BANK — A NEW TECHNIQUE FOR RAISING LARGE SCALE BAMBOO PLANTING STOCK

Regular availability of Bamboo seed is not assured. Gregarious flowering yields huge quantity of seed which is much in excess of the planned annual requirement. This huge bamboo seed stock can also not be stored for a long time as its viability reduces with storage period. After one year of storage, the germinative capacity drops down from more than 80 per cent in freshly collected seed to less than 40 per cent in seed stored for a period of one year or so. If the seed is stored for 18 months to 2 years, the viability is further reduced to less than 10 per cent and after this period, the seeds fail to germinate.

Storage of huge stock of bamboo seed is also not possible as not many well equipped godowns

are available with Forest Department. Cold storage would not be feasible on account of non-availability of fund and lack of storing facility for this product. Damage in storage due to rats is also enormous and, therefore, most useful method of utilizing the huge bamboo seed stock is to sow it in vacant lands in the nursery to serve as planting stock for 3-5 years period. This method of utilizing bamboo seeds has been experimented at State Forest Research Institute, Jabalpur. In this method, instead of bamboo seedling, its rhizome is used for planting. Such areas are called Bamboo rhizome banks.

In this practice, the area is thoroughly ploughed and fenced. The ridges, 15-20 cm, high are made at an espacement of 15-30 cm depending upon the period for which the stock is proposed to be used. If the whole stock is to be liquidated in 1-2 years, the ridge spacing of 15-20 cm is quite alright. But if the stock is intended to be used for a number of years, a wider spacing of say 20-30 cm may be desirable to encourage better rhizome development. The seeds are sown along ridges at a distance of about 5 cm all along the ridges. About 15-20 kg seeds would be sufficient for one hectare. The sowings may be done at the end of June or with the onset of monsoon. Three weedings and application of farm yard manure ensure early rhizome formation. The normal expenditure in preparing one hectare stock is as follows (on the basis of experiments conducted at Research centre, Jabalpur (SFRI) :

(A)	**Expenditure in Rs per hectare**	
i)	Ploughing of the area	Rs. 1,200.00
ii)	Preparation of ridges and sowing of seed	Rs. 4,250.00
iii)	Wages for weedings, waterings etc.	Rs. 1,736.00
	Total	Rs. 7,186.00
(B)	(i) Total plantable rhizomes obtained per hectare : 3,34,000	
	(ii) Cost of each plantable rhizome Rs. 0.021	

In third year, each running metre of ridge, on an average, yields about 10 plantable rhizomes. Accordingly, one hectare of such bamboo rhizome bank thus yields about 3,34,000 plantable rhizomes and this stock would be enough to raise about 500 hectares of bamboo plantations. The above-ground shoot portion is chopped off leaving about 30-45 cm stalk above collar level for the convenience of handling in transport and actual

planting in fields. Survival of this planting stock has been tested in different edapho-climatic regions of Madhya Pradesh. Survival of more than 80 per cent has been recorded. The survival can be enhanced if the damaged rhizomes are eliminated from planting.

Bamboo rhizome banks can also be managed to last for more than one year. For this purpose, extraction of rhizomes from each clump can be done to cover only the year's requirement. Other rhizomes can be left to develop for extraction in subsequent years.

This technique of creating bamboo rhizome banks can thus save lot of expenditure required on nursery and polythene bags, and can act as a source of sustained supply of planting stock for 3-5 years. The problem of seed availability in lean years and difficulty in its storage in the years of bumper production (gregarious flowering) can thus be tackled effectively and more purposefully.

4.31 Splitting of Bamboo Seedlings :

Excess seeds can also be sown in the sunken germinations beds. Drill sowings at an espacement of 15 cm are advantageous. The plants are allowed to grow in beds till February. In March, they are individually dug out and split into a number of seedlings. Each such seedling has one shoot and a number of fresh looking rhizomes, which may number from 2 to 7. The shoots, if unduly long, are clipped above 45 cm. They are pricked in standard - size polythene bags and kept in storage beds. Watering is done in the usual manner and in due course, they are ready for planting.

In future, when bamboo seed collection from plantations is organized in a surer and firmer manner, it would be desirable that seed source of each bamboo plantation raised is carefully recorded. It would also be necessary to mention if the seed was from sporadic flowering or gregarious flowering area.

4.32 Transport of Bamboo Seedlings from Nursery to Planting Site :

Transport of polythene-bagged seedlings from nursery to planting site is a costly operation, apart from the fact that transport vehicles are difficult to obtain and mis-handling of seedlings during transport may cause their death. A survey conducted to assess the loss of planting stock during transportation has revealed that 2.5 per cent of

planting stock is damaged on account of mis-handling. The loss, when calculated on State level, works out to a huge amount. Considering the annual target of about 1.00 lakh hectares of plantations of various species requiring about 250 million plants raised at an average cost of 125 million rupees (Rs. 0.50 per plant), the loss @ 2 per cent of the planting stock works out to 25 lakhs and @ 5 per cent loss of planting stock works out to the loss of more than 62 lakhs of rupees. Suitable sized crates, made of tin and other light material, can be used to transport the plants from nursery to planting site. Naked rhizomes from 'rhizome-banks' loosely kept in moist gunney bags, are more convenient than whole size potted plants for transportation.

To ward off ill-effects of mis-handling during transport, it is necessary to insist that the polythene sheet used in making polythene bags is not thinner than 150 gauge.

The transport of seedlings from the nursery to planting site should be arranged well before the commencement of rains. The seedlings may be stored near the planting site where some water is available for two to three waterings. If there is likelihood of difficulty in obtaining water, some arrangement may be made in advance by preparing low anicut, digging water-hole, etc. However, if 'rhizome-bank' is available, the rhizomes can be extracted and transported directly for planting out in the fields.

Watering should be stopped fifteen days before the actual date of transporting seedlings from nursery to planting site. The seedlings, thus, acquire hardiness and polythene bags with seedlings remain light for carriage with larger number per truck-load. On arrival at plantation site, they should again be watered at 10 days interval till the seedlings are planted out.

4.40 BAMBOO PLANTATION SITES :

Deep, loamy or alluvial and well-drained soils are the best for growing bamboos. The minimum standards of a bamboo plantation site are, as follows :

(1) Rolling or undulating topography is preferable. Dead flat areas having impeded drainage and accumulation of clayey soil should be avoided.

(2) Red murramy (weathered laterites) or coarse-textured soil with a minimum depth of 30 cm is tolerated but the growth is generally poor.

Only III quality stands may be expected to grow.

(3) There should be free surface drainage, as well as unimpeded sub-soil drainage.

(4) Sites having stiff-clay or water-logged soils should be avoided.

(5) There should be no iron, clay or kankar pan within a depth of 45 cm.

(6) Yellow wash soil, black or brown deposition soils, stiff shallow soils and excessively rocky areas should be avoided.

(7) Skeletal soils may support III quality bamboo stands, if moisture conservation devices are provided.

For selection of proper sites for bamboo plantations, the information given in Table 5 would be useful to all practising foresters.

Table 5 : Site selection for Bamboo plantations

Species	Climate	Soil	Technique
B. Vulgaris	(1) Moist and semi-moist	Clay and other heavy soils	Without irrigation, but soil working for moisture conservation necessary.
	(2) Semi-dry	Clay-loam	Frequent irrigation needed.
	(3) Dry	Heavy and loamy soils	Irrigation annually throughout.
D. strictus	(1) Semi-dry	Loamy and light soils	Without irrigation.
	(2) Dry	—do—	Without irrigation but moisture consevaration measures necessary.
B. arundinacea	Moist	Loamy soils along water courses, with moist sub-soil	Without irrigation.

4.41 Fencing :

Each nursery must be securedly fenced with a barbed wire fencing, and coupled with a live-hedge from inside. The wooden posts used should be stout and firmly fixed in the ground. They should be at a spacement of 3 to 4 metre, keeping the wire well-stretched. Four strands of wire should be used, and their spacement from the ground level should be 25 cm at first strand, 30 cm between first and second strands; 40 cm distance between second and third and similar distance between third and fourth strands. The sequence of fixing barbed-wire strands are shown in Fig. 1.

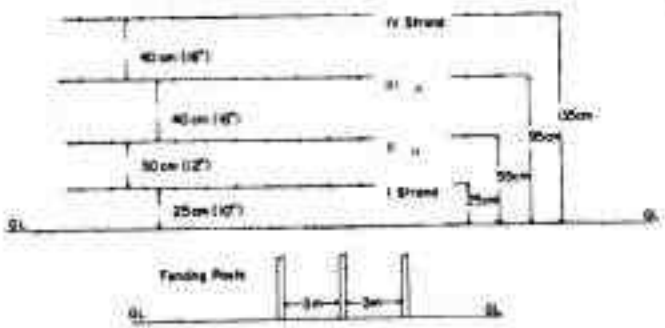


Fig. 1. Sequence of Barbed wire fencing in plantations.

Fencing of plantations is a very costly operation, yet at many places, no plantation can survive unless grazing is meticulously excluded by erecting an effective fence.

Fencing may be of trench-and-ridge (cattle proof trenches) or barbed wire. Cattle-proof trench fence is easy to provide, is comparatively less costly, and the cost of effective maintenance is almost negligible. Barbed-wire fence is very costly. Difficulties arise in procuring large quantities of barbed wire also. Subsequent maintenance of barbed wire fencing, however, is less costly than the cattle-proof trench fencing (trench-and-ridge). For the continued effectiveness of these two fencings, appointment of a plantation guard for a plantation unit of 250 ha compact block or a casual daily labour for each unit of about 100 hectares is absolutely necessary. The villagers have a tendency to fill up the trench and make a way to take their cattle inside the plantation area.

The order in which provision of fence to an individual plantation area should be decided upon, is as follows :

i) Trench-and-ridge fencing (cattle-proof trench) or stone-wall in areas where loose stones are available on spot.

Table 6 : Comparative economics of various fencing material.

S. N.	Type of fencing	Cost of fencing material	Expenditure for 100 hectaes		
			Labour charges	Total expenditure for 100 hectares	Cost of fencing per ha.
		Rs.	Rs.	Rs.	Rs.
1.	Stone-wall (Loose-stone, collection of stone as cost of material)	4000	48000	52000	520.00
2.	Trench-cum-Ridge (Cattle Proof Trenches)	—	48000	48000	480.00
3.	Trench-cum-Ridge with Thorn fencing	—	48000 15000	63000	630.00
4.	Trench-cum-Ridge with live hedge	—	48000 12000	60000	600.00
5.	Barbed-wire fencing	61800	8000	69800	698.00
6.	Combination of Trench-cum-Ridge with barbed-wire fencing	61800	56000	117800	1178.00

ii) Combination of trench-and-ridge and live hedge fencing.

iii) Combination of trench-cum-ridge and thorn-fencing.

iv) Barbed wire fencing.

v) Combination of trench-cum-ridge and barbed-wire fecing.

Comparative economics of various fencing material has been given in Table 6. The items of expenditure have been tested under Jabalpur con-

ditions for square shaped area measuring 100 hectares. The casual daily wage rate of Rs. 10.00 has been taken into consideration.

If stones and small boulders are available on the spot, the stone-walls can also be constructed. The top-width of the wall can be kept as 1.25m. Loose friable soil to a height of about 30 cm should also be put on the top of stone-wall so that the wall top is stabilized.

Trench-and-Ridge fence may be provided where soil is firm and no larger stones occur within 1 m depth from the ground level. The trench is a trapezium in cross section. At top, it is 1.25m wide, 0.90-1.00m deep, and 0.60m wide at the base. The dug out earth is heaped as a ridge inside the fenced area, at a distance of 15 cm from the trench. Such a ridge is usually 1.25m at base and 0.60m in height. If necessary, the upper width of the trench may be widened further by 30 cm, if its sharp edge, opposite to ridge is rounded off. Section of a typical trench-cum-ridge is illustrated in Fig. 2.

The ridge may be thickly sown with treated seeds of **Acacia** species to provide additional safeguard. It may also be stocked with close-planting of **Agave** bulbils.

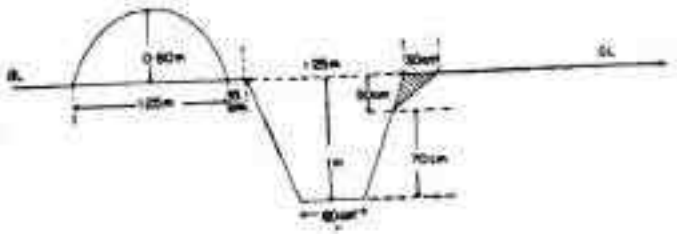


Fig. 2. Section of Trench & Ridge Fence (Cattle Proof Trench)

Trenches should not run across the contours, as they usually turn into big 'nalas' by gushing water in them. On moderate slopes, breakers, should be provided at 25 to 30m intervals so that erosive force of running water may be minimised. In such circumstances, it is also necessary to seed the trenches with suitable grass species. This practice further reduces the chance of active erosion.

If very variable terrain and soil are available, a combination of trench-and-ridge and barbed-wire fence may be adopted. Trench-and-Ridge fence may be provided wherever possible and elsewhere it may be combined with barbed-wire fence. Barbed-wire fence will, thus, be necessary at 'nala' crossings, stony ground, loose soil and rugged terrain.

Barbed-wire fence should be attempted only as a last resort. It should have only three strands (first at 27 cm from ground, second at 60 cm from ground and third at 105 cm from ground level). Fence posts should be about 2m long and 45-60 cm in girth at thick end. The thick end should be firmly buried in the ground upto 60 cm. Depending upon the gauge of wire and pliability of metal used, the interval between successive fence posts may vary from about 3 m to 4.5m. To effect economy, this distance should be precisely determined for the barbed-wire in hand. The maximum distance between two successive fence posts is the one over which the barbed wire remains fully stretched without sagging and without pulling down the fence posts.

For the added effectiveness of the barbed-wire fence, thorny twigs may be inter-twined in the barbed wires. No barbed-wire fence remains continually effective, unless it is looked after constantly by specially appointed fence-guards or 'chowkidars'. If the barbed-wire fence is required to be in position for 8-10 years, as is usually the case in bamboo plantations, it is preferable to replace the wooden fence posts with angle-iron posts, if funds become available. Angle-iron posts may be re-used from plantation to plantation, in the long run and they are cheaper than the wooden posts.

Thorny bushes, if easily available in areas close to the plantation, should be cut and fastened in the ground, all along the trench. Though these thorny twigs are not lasting, they provide extra protection to the plantation in the first year of formation. Thorny bushes are also available from the clearing of plantation area and their use should be made for fencing at comparatively little additional expenditure.

4.42 Plantation Site Preparation :

Plantation site should be cleared of all unwanted growth and saleable material disposed off by the end of November. Debris, if left, should be collected on approximately planting spots and burnt by the end of January.

It is preferable to divide plantation area into plots of 10-25 ha by laying out 3-metre-wide roads. Such roads not only facilitate inspections and expeditious movements of plants, etc. during the planting season but also serve as fairly effective fire-lines.

Table 7 : Proposed planting spacement for different climatic regions.

S. N.	Type of plantation	Climatic Regions		
		Moist localities	Semi-moist localities	Dry localities
1.	Pure bamboo plantation	5m x 5m (400)	4.5m x 4.5m (494)	4m x 4m (625)
2.	Underplanting in Teak plantation	6m x 6m (278)	5.5m x 5.5m (331)	5m x 5m (400)
3.	Underplanting in natural forest	7m x 7m (204)	6.5m x 6.5m (237)	6m x 6m (278)

(Figures in brackets indicate the number of planting spots per hectare.)

4.43 Planting Spacement :

Planting spacement in bamboo varies from place to place. However, the past experience with bamboo plantations revealed that spacing given in Table 7 for different climatic regions may be useful.

For underplanting, spacement cannot be followed with rigidity. It may vary within reasonable limits, depending on the actual space available for planting.

As far as possible, bamboo or other woody stakes should not be used as they harbour termites. Pit digging may be done by simple aligning and measuring.

4.44 Soil Working in Plantation Areas :

Only pit planting should be done. Pits of size 45 cm^3 are considered to be most suitable for bamboo plantations. Digging of pits should be completed by the middle of March and dug-out earth should be allowed to weather till the end of May. Thereafter, it should be re-filled loosely in the pits, by discarding larger pebbles and stones.

When planting out on hard lateritic soils and

other refractory sites, the original soil in the pit should be replaced by good silty loam from perennial stream-bed.

4.45 Planting out :

Planting out should commence only when the rains have set in and soil is wet to a depth of about 15 cm. Pits must be well soaked with water.

Planting in the pits should be done in the normal way by neatly removing the polythene bags. The soil column obtained from the bags should remain fully intact and without breaking. Planting should be done in such a way that plant collar is slightly buried in the ground and the soil is pressed firmely all around but no depression should be formed there. Care should be taken that shoots are not broken (in case of seedlings) either in transport or during planting.

Planting operation should be completed as expeditiously as possible. Generally, it should not prolong beyond July.

4.46 Moisture Conservation Devices :

In a plantation area where soil is sandy or very compact, provision of moisture conservation device to individual plants is necessary. The device provided should be effective in trapping rain water around the plant and storing it in the root zone for prolonged utilization, when rain season has ceased.

Saucer and mound device can be provided. Diameter of the saucer should be about 125cm. Having marked the edge of the saucer on the ground, it should be dug to a depth of 10-15 cm. and dug out earth should be used partly in making a small ridge around the saucer and/or small mound at the base of the planted seedling. A line diagram depicting the section of saucer-and-mound has been illustrated in Fig 3 (a).

Fig. 3 (a). Line diagram indicating planting pattern & moisture conservation devices.

If there is fair slope in the ground, the ridge at the lower edge of the saucer should be made much stronger and at the upper edge, it may be wholly omitted. It is preferable if the lower-edge of the ridge is also provided with small stones from the outside. The pattern of planting with the

moisture conservation device discussed as above, has been shown in Fig. 3 (b).

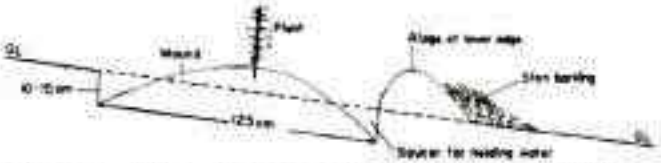


Fig. 3(b). Line diagram showing pattern of planting & moisture conservation device on slopy ground.

4.47 Establishment of Bamboo Seedling after Planting out :

After planting out, as soon as new shoots start arising from the ground, it is safe to presume that the plant is fully established. It takes about 15 to 20 days for the average sized planting stock (shoot-height 45-60 cm) to establish. Larger plants start drying up on planting out and their establishment period may extend over one month or more. Smaller than average-sized plants establish in reasonable time, provided there is no acute plant competition.

4.48 Use of Chemical Fertilizers in Plantation :

Fertilizer application in the early stages of plant growth is considered essential. However, at later stages, the fertilizer doses have not been found to significantly affect the clump formation or any other growth parameter.

For providing impetus to the early plant growth, N and P formulation is preferable. If it is not available, a mixture of urea (25%) and superphosphate (50%) may be prepared. Mixture of this chemical fertilizer at the rate of 30 gm per plant may be provided to each plant in the first week of September.

In plantations of dry areas, the same dose should be repeated at the beginning of the rains, in the 3rd and 5th year of formation.

The best results (in terms of initial plant growth and clump formation) can be achieved if locally available Farm Yard Manure (FYM) at the rate of about 10 kg per pit is mixed with the soil refill at the time of planting.

A fertilizer experiment, using 4 doses of urea (N) and 4 doses of superphosphate (P) was laid out in the bamboo plantation **(Dendrocalamus strictus)** in the year 1973 at Jabalpur.

Fertilizer doses in 16 combinations were applied per plant: first dose in 1973 in a ring 10 cm away from the plant and second dose in

1975 in a ring 20 cm away from the plant. Urea (N) was applied in four doses (0, 15, 30 and 60 g per plant) and single superphosphate was applied at the rate of 0, 25, 50 and 100 g per plant.

Splitted rhizomes (21 months old) were planted at an espacement of 4 m x 4 m in July, 1973.

Data regarding survival per cent, average height of culms, average girth of the culms and number of culms per clump have been analysed and summarised in Table 8.

The results have been presented in Table 8.

Analysis of data did not show any significant effect due to fertilizer application on recruitment of culms per clump. In fact control and fertilizer application appeared to have identical results in terms of number of culms per clump. From these results, it is evident that fertilizer application may be useful only in the initial stage of plant growth. When clumps are fully established, the self-sustainable ecosystem is attained and, therefore, fertilizer application may not have any growth stimulating effect.

Table 8 : Effect of fertilizer application on recruitment of culms :

	Number of culms per clump						
	N_0	N_1	N_2	N_3	Mean	S.D. ±	S.Em. ±
P_0	28.5	49.4	29.4	39.8	36.8	9.85	4.93
P_1	57.3	25.9	36.7	31.0	37.7	13.77	6.89
P_2	32.3	22.2	37.7	27.4	29.9	6.64	3.32
P_3	36.4	44.3	30.2	44.6	38.9	6.92	3.46
Mean	38.62	35.45	33.50	35.70			
S. D. ±	12.86	13.41	4.30	7.90			
S. Em. ±	6.43	6.70	2.15	3.90			

4.50 Casualty - Filling :

Having completed planting in an area, each plantation line will be systematically gone over and wherever plants are found dead or dying, they will be immediately replaced. This should normally be completed by the first week of August. Only average sized (shoot height 60 cm) plants should be used in casualty filling.

In the following year, as soon as the rains have set in, the plantation lines will again be systematically gone over, and all casualties should be duly replaced by plants having suitable shoot height (60 cm). Casualty-filling should be done after re-excavating the failed pit. Simultaneously, they should also be given a suitable fertilizer dose.

4.60 Weedings :

Only one weeding should be done in each of the year of formation and in the following year.

In the year of formation, weeding should be done just before the close of the rainy season, i.e., during the first fortnight of September. It should include :

1) Cutting-back of re-growth in 4m wide strips along the plantation lines.
2) Patch-weeding around individual plants upto a diameter of 1.25 m.

In the following year, weeding should be done during the second fortnight of August. It will include :

1) Cutting-back of re-growth in 4m wide strips along the plantation lines. These strips will be at right angles to the strips cleared in the year of formation.
2) Patch-weeding around individual plants upto a diameter of 1.25 m.
3) Renewal of soil moisture conservation devices.

4.70 Use of Pesticides in Plantations :

Generally, such an exigency does not arise. Where termite damage is feared, week solution of aldrine (1 : 250 solution of 30% aldrine) may be applied.

There are several other patent pesticides available in market and any of them can be used with fair convenience and advantage.

4.80 Protection from Pig Damage :

Pigs are the greatest menace to a bamboo plantation, especially in the year of formation. They

relish the succulent rhizomes and uproot the entire plants. Where the pig population is already at a dangerous level, this sort of damage is noticeable immediately after planting and continues sporadically throughout the rains. It becomes really severe after the winter rains, if normally received in the area, and persists its intensity till the soil hardens. The damage is practically negligible, once the plantation is established. Thorn fencing of individual plants is fairly effective in minimising this damage. Covering the saucer formed around individual plants with thorns is equally effective. This is a less expensive operation. A careful vigilance during the peak damage period (December to February) is of immense value in successfully warding off the damage.

5.0 UNDER PLANTING WITH BAMBOOS :

Simultaneous inter-planting of bamboos and tree species has never proved successful. Tree species have suffered the most and are usually wiped out completely. Growth of bamboos is also retarded to an appreciable extent. Simultaneous plantation of bamboo with teak, in many Divisions and a mixture of Bamboo, **Eucalyptus tereticornis** and **Leucaena leuccephala** in 1983 at Ashapur (Khandwa Division) have not been found successful. In the former case, it was teak and in the latter, it was bamboo which suffered in the mixture. It is, therefore, recommended that in future, no simultaneous inter-planting of bamboos and tree species should be attempted.

Underplanting of bamboos in well-established plantations is feasible. In this regard, the following principles may be carefully followed :

5.1 Teak Plantations :

Where plants have attained a minimum height of 5-6 m and have not flowered, underplanting with bamboos may be considered. Planting of bamboo can be undertaken only if, at least, the first mechanical thinning has been carried out. Coppice from felled trees should be constantly kept under check.

5.20 Eucalyptus Plantations :

No underplanting with bamboos should be attempted in well-stocked **Eucalyptus** plantations. This can be taken up only in such **Eucalyptus** plantations which have failed or are extremely understocked but the soil is capable of supporting bamboo crop. A minimum depth of 45 cm of top

soil is necessary. It must not be heavy in texture and should have no signs of water logging. Even incipient water-logging during the rains is inimical for the growth of bamboos.

5.30 Other Plantations :

Bamboo underplanting may be undertaken if the plants are more than 5-6 m in height and at least first two thinnings have already been made. Soil requirements for the growth of bamboos should also be fulfilled (vide, under **Eucalyptus** plantations).

Bamboo underplanting in natural forest is to be decided and undertaken after careful consideration. The following principles should be adhered to :

5.31 Mixed Forests :

Bamboo underplanting may be done where all under-growth and under-storey have been cleared and the top canopy trees are heavily thinned, and they are high in stature. Underplanting of bamboos in mixed forest may be done in degraded and understocked forests. No planting, directly under the standing trees, should be done.

5.32 Sal Forests :

This should be done in II quantity sal forests and only in those sal forests where sporadic bamboos occur naturally in them or in adjoining areas. Undergrowth and lower storey should be cleared and top canopy trees should be heavily thinned. Planting, directly under standing trees, should be avoided.

5.33 Teak forests :

The overwood, wherever necessary, should be thinned heavily prior to bamboo under-planting, so that the left-over trees are spaced out at a distance which is roughly equal to 1/3 to1/2 of height of the trees left standing in the area. With the excessive biotic pressure on natural forests, many of our teak areas have been rendered understocked. Such areas need to be protected and underplanted with bamboo. In many areas, where bamboo existing in understorey has flowered, its seedlings continue to be in a stage of suppresion. When such areas are closed, the suppressed bamboo seedlings have chance to come up. With some soil working and weeding, the revival of bamboo under-storey in a short span of 5-6 years has been successfully demonstrated.

5.40 Manipulation of Overwood where Underplanting with Bamboo is done :

If heavy thinning in the overwood, as prescribed prior to bamboo underplanting, is done properly, it is unlikely that any further manipulation of the overwood will be necessary. In the seventh year after the planting, the area may be gone over carefully and if necessary, a few trees from the overwood may be removed to favour bamboo growing underneath.

In plantations, further growing space will automatically be provided with continuing periodic thinnings.

6.0 IRRIGATED PLANTATIONS OF BAMBOOS :

Wherever water is available or may be made available at reasonably low cost, irrigated plantations of bamboos should be attempted.

Soil working is done in the form of ditch-and ridge. A typical cross-section of irrigation device is illustrated in Figure 4.

The ditches are laid down, with reference to contours, so that watering in the entire plantation is done through gravitation only. Ditches are 5m apart. On ridges, bamboo planting is done at 5m intervals.

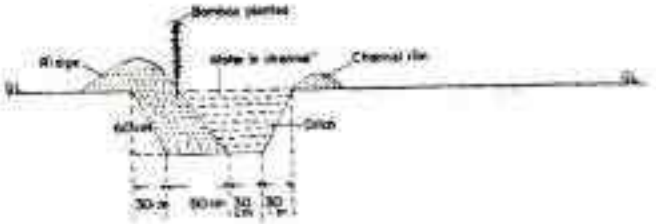


Fig. 4. Showing the irrigation method for Bamboo plantations.

No watering is necessary during the rains. During the rest of the year, 6 to 10 irrigations are provided and at each irrigation, water provided is roughly 500 cu m per ha. Productivity of irrigated plantations is 3 to 5 times that of the rain-fed plantations. They are particularly necessary where maximum production over minimum area is required. Such situations arise in raising bamboo **nistar** plantations in heavily cultivated areas, and industrial plantations to feed the industry with raw material close at hand. Semi-treated industrial effluents from paper and pulp industries, can be recycled for raising irrigated plantations of bamboo. Experiments at Nepanagar centre of S F R I have revealed that irrigation with the industrial effluent gives better results than fresh water irrigation.

Recycling of paper and pulp effluent for raising irrigated plantation also helps in reducing the pollution hazard to the perennial source of water to which it is released in a large quantity.

7.0 CLEANING IN BAMBOO PLANTATION :

Cleanings will be done in the 3rd and 7th year, of formation. Each time, cleaning is done, the following operations should be carried out :

(1) All dead, dry, switchy and damaged culms should be cut, subject to a minimum retention of 5 live culms.

(2) Around each plant, a circle of 2 m diameter should be marked, and soil should be worked to a depth of 15 to 20 cm. The dug out earth should be arranged to give a rim on circle edge, and a low mound at the base of the plant. Such a soil working helps in conserving moisture for the growth of the plant and development of rhizomes to form fully-developed clump in the shortest possible period.

(3) If the plants have not attained the desired growth, fertilizer application may also be made.

(4) All re-growth interfering with the development of bamboo clumps should be cut-back.

8.0 ASSESSMENT OF PLANTATIONS RAISED :

Periodic assessment of the performance of individual plantations is absolutely necessary. The following assessments are, therefore, prescribed :

These assessments should be carefully com-

Year of plantation	Dates of Assessment			
Current year's plantation	September (Soon after planting)	December	April	June (Before rains)
Two-year Old plantations	—	-do-	—	-do-
Three-year Old plantations	—	—	—	-do-
Seven-year Old plantations	—	—	—	-do-

piled and computed. Actual assessment data should be filed in respective plantation journals, together with assessment report. Copy of the assessment report should also be submitted to the Conservator of Forests within one month of the prescribed date of assessment. These assessment reports should be made use of in planning such operations as casualty-filling, providing moisture-conservation devices, application of fertilizers, cutting-back of interfering re-growth, warding off termite and pig damage, etc.

These assessments will be carried out by laying out indicator lines. Each plantation should have a minimum of two such lines, and one line for each unit of 40 ha of plantation area. Each line should be laid out in such a manner that it attains the longest possible length and covers practically all the topographical and soil variations available in the plantation. There should be no correlation between such lines, except that they should be at a reasonable distance from each other. If unavoidable, they may also intersect each other. The lines should be indicated on the ground by erecting small mounds, which should be at a distance of 100 metres apart or multiples thereof, and should also be serially numbered for each line separately. These lines should also be marked on the trace of the plantation. A line chart may be maintained showing position and number of mounds, and the associated plants with the line. The plants which come within 3 to 5 metres of it, on either side, should be located on line chart and also given serial numbers on this chart. At each assessment, the following recordings, in respect of each plant associated with the indicator line, should be made :

Plantation : ..... Year of Formation : ..... Indicator Line : .....
Date of Assessment : ..... Assessment made by : .....

S. No. of plant	Existing or Missing	Health			No. of culms				
		Healthy	Partially Dead	Dead	Karla	Mahila	Others alive	Dead and Damaged	Total
1	2	3	4	5	6	7	8	9	10

Av. culm Measurements		
Height (m)	Girth (cm)	Remarks (if any)
11	12	13

8.10 Nursery and Plantation Records :

For each nursery, existing or established and each plantation raised, full records of various operations carried out and expenditure incurred should necessarily be listed. These records may be called the "Nursery and Plantation Journals". They may be in the form of bound registers or ordinary files.

For each nursery, a separate journal is necessary. Similarly for each plantation, a separate journal is essential, but for a planting centre, if found convenient, such journals may be put together.

All operations carried out and expenditure incurred should be noted with all the necessary details. Some expenditure may be charged in the Divisional office also. Details of these expenditures should also find place in these journals.

For details to be incorporated in nursery and plantation journals, Forest Department Bulletin No. 5 may also be consulted for guidance.

For bamboo plantation, it is absolutely necessary to keep a clear and full record of seed source and if the seed is from sporadic or gregarious flowering.

A large-scale trace of the plantation area should also be filed, showing position of indicator lines and mounds representing the same. Similarly, associated plants with these lines should also be marked. Periodic assessment data of plantations, together with assessment reports, should also be filed in respective plantation journals.

PROFORMA PROJECT REPORT FOR BAMBOO PLANTATION

(To be prepared, at least one year in advance before planting, by the Range Forest Officer, should be verified by Asstt. Conservator of Forests and Approved by Divisional Forest Officer / Divisional Manager).

A. Basic Information

1. Year of planting :
2. Area to be planted (ha) :
3. Plantation scheme under which planting is to be done :
4. Objectives of the plantation :
   Under planting :
   Industrial plantation :
   Other objectives :
5. Species to be planted :
6. Spacing of plants :
7. Planting site :
   (I) Name of officer who selected the site (Site selection should be done only by a gazetted Officer) :
   (II) Location :
      (a) Range
      (b) Compartment
      (c) Approach :
      (Give details about the position and condition of roads)
   (III) Soil :
      (a) Sandy/Loamy sand/Sandy loam/Loam / Clayey loam / Clayey
      (b) Gravelly / Bouldery / Lateritic, etc
      (c) Fertility Status : High/ Medium/poor
      (d) State of drainage : Water logged/ Well-drained.
   (IV) Topography :
      (a) Configuration of the ground (Plain/gently slopy/hilly etc).
      (b) Percentage of slope (approx.)

(V) Climate :
- (a) Mean annual rainfall
- (b) Number of rainy days and their distribution
- (c) Mean max. temperature
- (d) Mean min. temperature
- (e) Highest temperature
- (f) Lowest temperature
- (g) Mean atmospheric relative humidity

8. Availability of plants :

(I) Procurement of seed
- (a) Quantity of seed required
- (b) Quantity of seed already available in stock
- (c) Quality of the available seed
  - (i) Source
  - (ii) Graded / Ungraded
  - (iii) Treated / Untreated
  - (iv) Whether collected depatmentally / purchased from private seed suppliers / obtained from the SFRI/obtained from other divisions.
- (d) Quantity of the seed to be procured
- (e) How and from where it will be procured ?

(II) Nursery :
- (a) Location of the nursery
- (b) Type of the nursery (Permanent / Temporary)
- (c) Area of the nursery
- (d) Average lead from the planting site
- (e) Availability of water
  - (i) Source
  - (ii) Distance from the source
  - (iii) Average daily availability of water
- (f) Number of plants (of the species to be planted) already available in the nursery
- (g) Condition of the plants
  - (i) Polypotted/Rhizomes etc.
  - (ii) Average height of the plants
  - (iii) Average age of the plants to be used (in months)
- (h) Number of new plants to be raised

(i) When and how these plants will be raised and what will be the age of plants at the time of planting ?

9. Transportation of plants :

Mode of conveyance to the planting site (Trucks / Bullock - carts / Head-loads)

10. Protection :

(a) State of biotic factors
(b) Proposed method of closure (Cattle-proof trench / barded-wire fence/stone wall etc)
(c) Total perimeter of the area to be closed.

11. Executive Staff :

(Give names with designations of the Foresters and/or Forest Guards, who will be responsible for the execution of the planting work).

1.
2.
3.

12. Supervisory Staff :

(Give the names and designations of the Forest Ranger/ACF, who shall supervise the plantation works)

1.
2.
3.

B. **Nursery and Planting Techniques**

(Give in brief the type of seed treatment, type of plants used, size of pits, type of soil working and soil change, quantity and time of application of manure/fertilizers/ weedicides / insecticides etc., types of weedings, intensities and frequency of thinnings etc).

C. **Time Table of Various Operations**

S. No.	Name of the operation	Period by which the operation must be completed		
		Year	Month	Week
1	2	3	4	5
1.	Seed procurement			
2.	Seed treatment			
3.	Seed sowing			
4.	Transplanting			
5.	Demarcation and site-clearance			
5.	Burning			
7.	Fencing			
8.	Staking			
9.	Digging of pits			
10.	Erection of temporary hut			
11.	Transportation of plants to the planting site			

S. No.	Name of the operation	Period by which the operation must be completed		
		Year	Month	Week
1	2	3	4	5
12.	Planting			
13.	Weedings			
	(i) First weeding			
	(ii) Second weeding			
	(iii) Third weeding			
14.	Fire protection			
15.	Application of manure			
16.	Application of fertilizers			
17.	Application of insecticides			
18.	Application of weedicides			
19.	Any other operation			

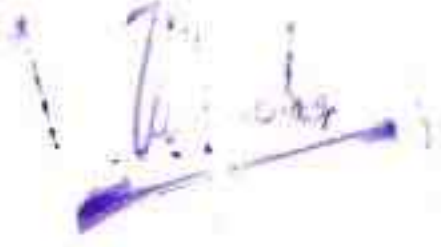
D. **D. Cost Estimates**

S. No.	Work	Quantity of work	Rate	Estimated expenditure
1	2	3	4	5
	First Year of Planting			
1.	Seed procurement			
2.	Cost of raising plants in the nursery			
3.	Transportation of plants to the planting site			
4.	Demarcation			
5.	(a) Site clearance			
	(b) Any special attention like eradication of **Lantana** growth			
6.	Burning			
7.	Fencing			
8.	Staking			
9.	(a) Digging of pits			
	(b) Any special soil working required			
10.	Erection of temporary hut			
11.	Planting			
12.	Weedings			
	(a) First weeding			
	(b) Second weeding			

1	2	3	4	5
	(c) Third weeding			
13.	Fire protection			
14.	Application of manure			
15.	Application of fertilizers			
16.	Application of insecticides			
17.	Application of weedicides			
18.	Watch & ward			
19.	Any other work not covered above			
20.	Contingencies			
	Second & Subsequent Year of Planting			
1.	Maintenance of fencing			
2.	Application of insecticides			
3.	Weedings			
	(a) First weeding			
	(b) Second weeding			
	(c) Third weeding			
4.	Watch & ward			
	Grand Total for one year			

1	2	3	4	5
	Total expenditure likely to be incurred during the first five years after planting			
	Average expenditure per hectare			

E. **Any other point of specific mention**



Divisional Forest Officer/
Divisional Manager

F. **Remarks of the inspecting officers**