Improvement of seedling production system in forestry sector and its impact on seedling health

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More than 120 forestry species are being utilized in India for various afforestation programmes. Among these, teak (*Tectona grandis*), eucalypts (*Eucalyptus grandis, E. tereticornis*), acacias *(Acacia auriculiformis, A. mangium*), and poplars (*Populus* spp. are exploited on a large-scale and the annual planting rate is about 1.78 Mha. Production of planting stock and stand establishment are affected by various limiting factors, of which diseases play a major role. The introduction of root trainer technology has made a tremendous impact on forest nursery seedling production. The technology offers production of large number of healthy, uniform-sized planting stock within 90 days. Using the technology also improves the quality of seedlings and clonal plants since it allows for growers to better manipulate mycorrhizae, biofertilizers, biopesticides and micronutrients. The other advantage over seedbed and polythene container nurseries is that root spiraling of seedlings can be avoided. However, the technology needs further optimization and growing media have to be developed and standardized depending on the seedling crop, local climatic conditions, and the planting technique to be followed. This paper highlights the modernization of planting stock production system and its impact on nursery management.

Introduction

Even though, forest tree seedling production systems has been revolutionized in many countries, in India, production of planting stock is still largely depended upon conventional methods. In forest nurseries, from 1970 onwards polythene containers of different sizes have been used on a large-scale for raising seedlings and for transplanting bare root seedlings. The technology in vogue is economical, however, spiraling or coiling of roots in seedling crops, especially in eucalypts, is one of the disadvantages. Since 1985, various forest industries and research institutions have tested different types of containers for growing seedlings. However, very recently root trainers were introduced in the forestry sector and presently this technology is being widely used for growing planting stock of selected forestry species. Due to the tropical, warm-humid climate in many parts of the country, diseases and insect pests cause major havoc and they are often a limiting factor for raising and maintaining nursery stock. Under conducive microclimatic conditions, seedling crops of any forestry species may succumb to one or more diseases and pests. In India, climatic conditions range from temperate in the north to tropical warm-humid in the north-eastern and southern peninsula and hence incidence of diseases and pests in nurseries exhibits tremendous variation. Disease and pest outbreaks in forest nurseries in high rainfall areas often become drastic and most seedling species raised become seriously affected. As the disease and pest hazards in forest nurseries became very common they often affected entire planting programmes. Consequently, systematic studies and management of economically important diseases and pests were taken up during the 1980s and 1990s and nursery management practices for important forestry species were standardized (Mohanan 1997 and 2001, Sharma et al. 1985, Sharma and Mohanan 1991). Recently, Mohanan (2000) made a comparative account of the disease situation in root trainer and conventional nurseries. The study showed the tremendous improvement in seedling quality, and thereby stand establishment, resulting from using the root trainer, seedling production system.

Planting stock production

Forest nurseries play a vital role in all afforestation programmes. The quality of planting stock warrants not only successful field establishment, but also subsequent growth performance and high yield. Raising high quality seedling requires technical skills including careful planning for all the major components such as quality seed, appropriate growing media, root trainers/containers, nursery hygiene and protection. In India, forest nurseries become operational either throughout the year, as in the case of production of bare root seedlings (teak) for preparation of stumps, or during December to June, i.e. for raising fast-growing species like eucalypts and acacias. The seedling production system can be broadly grouped as either conventional and modern.

Conventional system

In this system, bare root seedlings are raised in seedbeds and polythene containers. The nurseries are established and maintained by the state forest departments in suitable sites which are close to the planting area in each year during December–July or at least 6 months before the proposed planting operations. Seedlings are grown in seedbeds of standard size (12 x 2 x 30 m) and for the first 45 to 60 days, a shade panel of either coconut leaves or other broad leaves is provided to protect the seedlings from sun scorch. The seedbeds are watered regularly and regulation of shade, water and seedling density is done depending up on the seedling crop. When seedlings reach a height of 10 to 15 cm, they are pricked out into polythene containers (18 x 12 cc) filled with forest soil. This occurs during February–March and for the first 2 to 3 weeks the container plants are kept under shade. The container plants are maintained till they are planted out during June–July (south–west monsoon). In general, seedling crops need to be maintained for at least 6 months; however, bare root, teak seedlings need to be maintained for 12 to 18 months for preparation of stumps, which are planted out directly during May–June.

In India, since 1970 polythene containers have been widely being used for raising forest nursery seedlings. Polythene containers of different sizes are used for either direct seeding or transplanting the bare root seedlings. Though, the polythene containers are handy and economical, they have the inherent problem of causing root coiling or spiraling. Seedling roots grow geotropically, but if they do not meet any physical obstruction, they may tend to grow laterally around the side of the container. Usually, root spiraling will not adversely affect growth of the seedlings in containers, but it can seriously affect stand establishment. Even though, spiraling can occur in almost any type of container, root spiraling is commonly observed in flat-bottomed, smooth walled polythene containers.

Root trainer system

Improvement of the planting stock production system, especially the introduction of root trainers and establishment of permanent nursery facilities in the forestry sector was initiated under a World Bank aided forestry programme. Central forest nurseries with facilities for raising and maintaining many quality seedlings, clonal multiplication facilities, composting and growing media development units were developed in different parts of each state to meet the need of annual planting programmes. Reusable type root trainers with different growing-cell sizes and capacities were used. The root trainer is a specially designed cylindrical container made up of opaque material with two open ends of which the lower end tapers gradually with a smaller open end, to provide favourable condition for the root development. Inside the root trainer, four to six ridges or ribs run longitudinally from one end to another, to prevent root coiling. When a root starts to touch ridge it immediately changes its course and grows downward thus avoiding coiling.

The principles of root trainer technology include: (i) providing appropriate environment to attain rapid development of primary roots and subsequent secondary roots, (ii) allowing early natural pruning of primary tap root and induce secondary root system so as to attain 'forced multiple taproots', and (iii) maintaining acute angle of secondary and tertiary root tips and its subsequent pruning, so as to keep downward movement to attain network of massive root system. The above principles aim at training the root in a desirable direction and enhancing the surface area for absorption with little or no injury or disturbance to the tender roots. Appropriate training of the root system is achieved by providing a porous, easily penetrable, nutrient rich growing medium with good drainage and proper aeration. Limiting the quantity of the growing medium induces root competition and thereby optimum utilization of the medium in the cells. Natural pruning of primary and secondary roots occurs by exposing the growing tips to sunlight and air, and thus induces strong vigorous multiple tap roots. Maintaining the angle of inclination in such a way that lateral roots should tend to develop downward, and providing taper in the bottom of root trainers results in a downward development of the roots.

Even though different types of root trainers are available for grow seedlings, reusable trays containing cells from which seedlings or ramets (clonal plants) can be removed at the planting site are the most preferred. Single cell and styrofoam blocks or composite trays are being widely used. Both seedlings and ramets are raised on a large-scale in root trainers. The size of the container for a particular seedling crop depends on both biological and economical features. Usually, cell volume in the root trainers for raising broad-leaved species ranges from 150–300 cc. However, optimum container size varies according to many different factors, including growing density, seedling species, size of seedling desired, type of growing medium, environmental conditions, and length of the growing season. The distance between the individual cells in the block influences seedling growing density, one of the most important container characteristics affecting seedling growth. The spatial arrangements of cell within the block also has economical implications, however, tree seedlings require a certain minimum amount of growing space, which varies with species and age. In general, root trainer seedling quality increases with a corresponding decrease in growing density. Since root trainer technology has only recently been introduced in India, several factors are yet to be determined for the optimization of the technology to suit particular climatic conditions, seedling crops and planting techniques.

The root trainer nursery certainly has many advantages over the seed bed and polythene container nurseries, not only in the production of quality seedlings but also in overall nursery management. Some of the advantages include ease of: (i) filling the growing cavities with growing medium, (ii) regulating the moisture regime in the container, (iii) applying fertilizers, micronutrients, biopesticides and biofertilizers, (iv) and other factors such as casualty replacement and handling and transport. Also, air pruning of roots produces actively growing rot tips and uniform sized hardy planting stock (seedlings/ramets). There is less shock to seedling resulting from transportation/outplanting and the nursery growing period is no more than 90 days.

Clonal nurseries

Clonal forestry on a large-scale was initiated in Andhra Pradesh State by ITC Paper Boards Ltd. during the 1980s. *Eucalyptus tereticornis* (hybrid) plus trees (healthy, resistant against pink disease) were selected and ramets were prepared on a large-scale for raising plantations for farm forestry and regular forestry programmes (Lal 1993). In Kerala State, clonal forestry has been initiated recently and many disease resistant clones of *E. tereticornis* and *E. grandis* were identified and ramets were prepared on a large-scale for fulfilling the needs of the State Forest Department (Balasundaran et al. 2000).

In root trainers, eucalypts seedlings and ramets can be raised, however, the method of production of ramets differs slightly on account of use of coppice cuttings as reproductive material. Single cell root trainers of 150 cc are usually used for raising the ramets. Various growing media such as vermiculite, perlite and soil/sand mixtures are being used. Rooting hormones usually employed include indole acetic acid (IAA), indole butyric acid (IBA), naphthalene acetic acid (NAA), and 2,4 dichlorophenoxy acetic acid (2,4 D). Of these, the most commonly used is IBA and it is used as a dip method, quick dip method and dry-dip smear method. Of these, the dry dip method is most commonly used for eucalypts and IBA (4000 ppm) is mixed with inert talcum powder and applied to stimulate root formation. The root trainers with the cuttings are initially transferred to the mist chamber and subjected to intermittent mist for 4 to 5 weeks until a good root system is developed and shoot growth starts. After initiation of sprouting, the root trainers are transferred to hardening units provided with sprinklers and shade nets to reduce sunlight and temperature. Nutrients (DAP and NPK mixture) are supplied to the ramets and an average plant height of 30 to 45 cm is maintained. The technology offers production of uniform sized, disease-free, healthy planting stock leading to higher and more uniform wood yield from the plantations.

Growing media

The common organic materials used as growing media include for example coir pith, sugar cane waste, saw dust, tree bark, forest weeds, paddy straw, wheat straw, and water weeds. Most of these organic materials benefit from composting and balances the ratio of carbon to nitrogen in the material. Among the inorganic components, used in the potting mix, for improving drainage and aeration are vermiculite, perlite, pumice, and sand. Composted organic material has all the chemical and physical properties of an ideal growing medium. Even though, any organic material is suitable for composting, the most vital factor for compostability is its C/N ratio, i.e. the ratio of carbon to nitrogen present in the raw material. The optimum range is 25–30:1 and at C/N ratio above 30, nitrogen must be added in the form of nitrogenous fertilizers such as urea or ammonium sulphate. In different states, forest weeds (*Chromolaena odorata, Lantana camera, Andropogon* s*p.Combretum* sp.,), wheat straw, coir pith, water weeds, and tea and coffee waste are used for composting. Usually, Berkeley's method is followed for making the compost. Depending upon the state, a slight modification of the process is being made in accordance with the availability of the compostable organic materials. Usually, the succulent shoots of desirable forest weeds are cut manually and transported to the chopping site where a manually-operated chopper machine equipped with double blades chops the materials to a size of 5–10 mm. Prior to placing the chopped material in the compost shed, 50% water by weight of total weight of the mixed material is added, to give a homogenous mass and to expedite microbial activity. Then the mixture is placed in the compost shed layer by layer and sprinkled with water. After a week when the temperature of the heap reaches about 55 °C, the heap is turned over and thoroughly mixed. In no case is the temperature allowed to exceed 60 °C as this would result in death of the microorganisms. Length of the period for completing the process depends on the plant species and the organic matter used. However, usually for forest weeds, within 30 to 45 days composting will be completed. The final product is dark brown and feels greasy and smells earthy. Depending on the tree species potting media are prepared by mixing the compost with soil and sand in different proportions.

Impact on seedling health

Introduction of root trainer growing practices and technological changes in producing planting stock has had a major impact on nursery management. As soil less or soil free growing media are used in root trainers, common soil-borne diseases like damping-off, seedling blight, and wilt seldom occur. However, the conventional nursery system which caters to the larger part of the requirement of planting stock, still suffers severely from the diseases. *Rhizoctonia solani* and *Cylindrocladium quinqueseptatum,* the major pathogens, pose threats to the seedbed nurseries. Under the conducive tropical climate, maintaining the nursery crop for a longer period is one of the most serious problems confronting nursery managers. During this period, diseases and pest problems occur in succession and if timely intervention is not done the entire seedling crop may be devastated by one or other diseases and pest attacks. However, in root trainers, seedling crops require a maximum period of 90 days of growth and hence rigorous management is possible. In conventional nurseries, seedlings have to be maintained in the seedbeds or in polythene containers at least for 6 months. During this period, diseases caused by different fungi and bacteria affect the seedling crop and often epidemic outbreak occurs (seedling blight caused by *Cylindrocladium* spp.) devastating the entire seedling crop. In root trainers, even if foliage disease occurs, the affected seedlings can be easily removed from the blocks and replaced with healthy seedlings, thereby avoiding the spread of the disease in the nursery. Similarly, seedlings showing poor or stunted growth or deformity can be easily replaced or corrected by application of appropriate nutrients. Since, root trainer seedlings exhibit uniform growth performance, prophylactic pesticide treatment, if required, and maintenance of seedling quality are easier than in the conventional nursery system.

Under planting stock improvement programmes, disease resistant and fast-growing ramets can be produced on a large-scale employing the root trainer technology. Screening of efficient clones for disease resistance at the nursery level can also be performed very efficiently employing the new technology. The new technology is very efficient and suitable for planting stock improvement using mycorrhizal, biofertilizer and biopesticide manipulation, since the root trainer technology gives more emphasis to healthy root system of the seedlings. Recently, in eucalypt, root trainer nurseries, planting stock improvement using *Pisolithus tinctorius*, an ectomycorrhizal fungus, has been carried out (Mohanan 2002a). Application of a fungal spore slurry and mycelial and spore pellets was easy and handy in this system. In teak (*Tectona grandis*), planting stock improvement through arbuscular mycorrhizal (VAM) fungal manipulation using root trainer seedlings also showed promising results (Mohanan, 2002b) and the root trainer technology offers quick assessment of mycorrhization of root system. As far as other nursery parameters like seedling density, shade over the nursery and water regime are concerned the system offers sufficient flexibility in operations. Seedling density can be controlled at the desired level at various seedling growth phases by emptying the cells in blocks in a non-destructive way. Similarly, seedlings of different tree species can be kept under shading of different intensity and duration. Control over water and nutrient regimes is also easy and handy in this system. Moreover, seedling health and quality can be assured by rigorous nursery management.

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