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SPECIAL CONCERNS

INDIGENOUS SEED PRACTICES FOR SUSTAINABLE AGRICULTURE

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A shift to sustainable agriculture (SA) requires fundamental changes to the seed production paradigm. It is important for farmers, particularly those in the Third World, to have control over their seed. This requires a knowledge and appreciation of alternative technologies for crop and seed production, genetic conservation, and crop improvement, as well as a thorough understanding of related issues. A seed production system along the lines of SA framework is based on holistic and integrative farming principles and a greater participation of farmers in all aspects of the seed industry. Indigenous systems, including seeds and associated practices, are a rich source of alternatives. However, these too have been misused, not only for profit, but also to gain a monopoly of the means of production, and to perpetuate the dominant yet unsatisfactory development paradigm.

INDIGENOUS KNOWLEDGE SYSTEMS

In the search for alternative approaches to SA, various sectors have shown that they are prepared to take a fresh look at indigenous knowledge systems. This is because they recognize that indigenous knowledge systems have a great deal to offer in terms of genetic resources, food, medicine, clothing, shelter, fuel, tools, techniques, and crop and animal protection. There is also a growing realization that certain characteristics of indigenous knowledge are highly compatible with the framework of sustainable agriculture. Indigenous agriculture systems are varied, adaptable, nature-friendly, and produce yields which are not necessarily lower than those of 'modern' or conventional agriculture. Unlike the latter, which stresses yield, indigenous agriculture systems emphasize production stability and risk minimization. They value human fulfillment above profit and are directed towards self-reliance and self-sufficiency.

The mainly subsistence nature of indigenous agriculture systems is a source of concern to many governments faced with the threat of overpopulation, degraded resource bases and global environmental changes, such as the depletion of the ozone layer. Moreover, misconceptions and biases against indigenous knowledge systems have hindered its incorporation into current development strategies and programmes. Nevertheless, in the absence of appropriate 'modern' alternatives, indigenous knowledge has become a starting point for academic and other institutions in their search for solutions. Indigenous knowledge can also be used to actualize the principle of cultural appropriateness, a basic feature of SA, incorporating into it the wealth of farming knowledge which resides with local people.

SEEDS

Indigenous knowledge systems, especially indigenous seeds, provide a logical starting point in the search for sustainable alternatives in agriculture. Seed is a basic input in production. It has always played a primary role in development programmes, through the high yielding varieties (HYVs) and associated technology and input packages such as monocropping, chemicals, irrigation, machines, capital, and credit or loans. To promote HYVs, the formal seed sector -- both official and private -- was operationalized to multiply and make available to the farmers the so-called 'improved' seed.

INDIGENOUS SEED PRACTICES

Indigenous seed practices encompass practically all aspects of crop production, since seed-saving is an integral part of cropping activities in indigenous systems. Farmers engaged in the production and multiplication of quality seed deal with asexual propagation, land preparation and soil management, seed and seedling preparation and care, crop and pest management, flowering induction, the enhancement of seed quantity and quality, crop improvement, harvesting or collection, seed processing (drying, threshing, cleaning, and grading), storage, genetic conservation, and quality testing.

The multifaceted focus and holistic approach which are a characteristic of indigenous systems have been observed and backed by five to six years of informal study on the part of the author and her colleagues, including laboratory tests for the validation of indigenous seed practices, survey and unstructured interviews with tribal Filipinos throughout the country. Observations were also based on discussions and exchanges during training sessions attended by farmers and development/rural workers, and feedback in the form of publications and written communications.

Local communities use various indicators to determine favorable times of planting and cropping, such as the different aspects of the sky, sun, moon, stars, bodies of water, and trees, as well as animal behavior. They have many different ways of preparing the seed for planting; some follow the principle of sympathetic magic, such as filling the mouth with porridge while planting coconut to get makapuno fruit[1] . Seeds may be coated with or soaked in various substances to ensure protection against pests or to promote growth. Sometimes seeds are dipped in blood (allegedly

[1] Makapuno is a mutant coconut whose cavity is filled with white meat (endosperm) in contrast to the normal coconut, in which the meat is only a few mm thick.

an offering to spirits, but possibly a form of nutrient enhancement), and fields are prayed over the night before planting, using lighted torches (which may actually kill many of the insect pests attracted to light).

There are various 'organic' methods in use for enriching or altering the soil, managing water, and keeping plants pest-free. Diverse or mixed cropping, specific cropping arrangements, and the use of plants that serve as repellants or attractants are common indigenous strategies for minimizing risks and enhancing stability. In the case of rice, some groups use special arrangements of varieties in a field to manage insects, rats and birds. Mechanical techniques, such as interesting sculpted bird perches, and insect and rat traps, and biological control strategies are also employed to remedy pest problems.

Plant manipulation to alter or improve crop performance such as grafting, injuring, pruning stems or roots, and 'training' plant parts can be traced back to indigenous systems. Plant characteristics may also be altered or pre-selected by means of a particular index. In papaya, for example, female trees can be obtained by selecting the part of the fruit where the seed is derived and the physical characteristics of the seed or seedling. Ingenious ways to promote flowering and fruiting are available (e.g., smudging, injuring, girdling, pruning, water manipulation), and indigenous harvesting and seed collection techniques have also been developed. As a rule, farmers select the most desirable produce for the next season's crop, which is in itself a form of breeding. In other cases, they practice hybridization, by deliberately growing crops side by side to obtain 'new types', or by hand pollinating female flowers with pollen from another plant. Farmers have also developed techniques of processing and drying (e.g., through the use of special dried leaves as an indicator of dryness). Rice seeds, for example may be sorted by flotation and simply winnowed. Some farmers carry out the harvesting, storage and planting of whole rice panicles. Techniques to ratoon, clone or produce asexually propagated materials are also available for some species that do not readily produce seed.

One of the most important concerns of farmers, seed producers, and seed traders is seed protection during storage. Storage is critical in the Philippines, as the climate is hot and humid and seed losses are often quite heavy. A number of relatively recent scientific studies undertaken to improve the physiological state of seed (i.e., by invigoration) and to enhance its storability and field performance are of an indigenous nature. Various methods have been devised to protect the seed from rats, including especially designed storage place, which generally keeps seeds dry and pest-free, thanks to the smoke from a wood-burning stove. There are also containers designed to keep out moisture (e.g., well-sealed gourds or bamboo tubes), or to keep seeds cool (e.g., moist earthen jars, cave interiors). Desiccants such as charcoal, ash, lime are also in common use. Botanicals (e.g., lemon grass, gliricidia leaves, hot pepper, and tobacco) are often placed inside containers or mixed with the seed to keep it insect-free. Some of these botanicals are also used during planting. The use of resistant indigenous seeds or varieties clearly plays a major role in the strategy aimed at crop health maintenance, seed longevity and pest management.

Seed quality is another constant concern for farmers contrary to the belief of many people in the formal sector. There are various ways to determine whether the seed is of good quality, such as germination testing using locally available material (e.g., banana leaf sheath), volume expansion with exposure to de-flotation, and a test for stickiness which some seed display in the presence of certain substances (ash).

Certain rituals or practices associated with cropping itself border on magic, religious belief, or superstition (e.g., planting sweet potato while naked). However, they serve definite purpose, by strengthening or institutionalizing the practice in order to ensure implementation, continuity and sustainability. For those practices that are more directly related to production, but for which no scientific explanation can be offered or which do not work when validated, judgment should be suspended until all possible explanations have been ruled out.

The current body of science -- especially when it is dealt with as discrete disciples or by means of a reductionist approach -- is admittedly still limited to explaining certain phenomena which people claim they have observed. Some of these practices are backed up by solid, scientific evidence, while others will need to be validated in more specific environments, taking into account the ecological, socio-cultural, economic and even political context. Interestingly, some of these indigenous practices, including rituals are share by farming communities who are in geographically isolated regions or who are not in contact with each other.

GENETIC RESOURCES AND SEED-RELATED ISSUES

The conservation of crop genetic resources and the promotion of biodiversity is a matter of course among peoples with diversified cropping methods, and diverse cultural and agricultural practices. Some communities, however, have developed specialized practices in gene conservation, not only for food security and general survival, but also for posterity. As a result, valuable knowledge and genetic resources that are useful for industrial purposes, agriculture and medicine are conserved. Most of these valuable genetic resources reside in the Third World -- also referred to as the 'developing world', 'gene-rich' countries or 'the South'. However, the majority of the international collections are now controlled by the First World -- also called the 'developed world', 'gene-poor' countries, or 'the North'.

Realizing the potential of genetic resources, the commercial sector has also intensified its interest in the conservation, use and control of such resources. The transnational companies (TNCs) which dominate trading, especially in seed, agrochemicals, pharmaceuticals and the food industry, also have a major interest in biotechnology. Various strategies have been utilized, and still more are envisioned, to enhance and protect the interests of companies, organizations and individuals whose business is dependent upon genetic resources and indigenous knowledge systems in general.

The great advances in biotechnology, with its potential for the manipulation and recombination of genetic materials, has further intensified the necessity for the TNCs to control and protect 'raw' materials and finished products.

The issue of the commodification of knowledge and drive towards the control of genetic resources and the materials derived from them has raised environmental, social, political, moral and ethical questions. There is an ongoing debate about the ownership of genetic materials, which are regarded as the common property of all humankind. The protection of varieties through patents or by means of a *sui generis* system, such as the Plant Breeders' Rights under the UPOV, has also generated questions concerned with propriety. Genetic materials and knowledge associated with them has come largely from the Third World, where farmers do not recognize private ownership especially of genetic materials, whether in the raw/wild form or as cultivars or varieties.

Biodiversity prospecting by corporate interests, TNCs, research institutions and governments continues (e.g., the Merck/InBio agreement, which by means of a contract with an NGO, grants that company the rights to the biological resources of Costa Rica). An aborted attempt to take control of the germplasm collection of the International Agricultural Research Centers (IARC) under the CGIAR by the World Bank is another example of a strategy aimed at obtaining a monopoly control of genetic resources.

One of the relatively more recent moves to control genetic resources and enhanced trade is the World Trade Organization General Agreement on Tariffs and Trade or GATT agreement specifically dealing with the issue of intellectual property rights (IPR) protection and trade liberalization. The TNCs are leading the call for GATT-based global patenting system to be enforced in developing countries. Life forms, including plant genetic materials and varieties, are now considered patentable materials.

An "internationalized" patent and a free trade policy would allow TNCs easy access to raw materials, restrict access by other parties, and make it easier to lay claim to them or to products derived from them. The charging of royalties and a further consolidation of the forces of the TNCs would thus be facilitated.

Ironically, many supposedly new discoveries or inventions are actually, "rediscoveries" or "reinventions", in the sense that they were developed and used by local communities as part of development "packages" are in effect indigenous seeds which have been renamed or slightly modified. Much of the material on which TNCs have made such a profit was derived from indigenous systems that are protected by patents or monopoly agreements. And yet this materials has not been used to benefit the actual source of the knowledge and resources involved. Worse yet, is has even become an instrument for the exploitation of the people.

Furthermore, international efforts on the part of the informal sector to promote the recognition of its contributions to the maintenance and development of genetic resources, and to protect its interests, have not kept pace with those of the formal and commercial sector. The International Model Law on Folklore, an UNESCO and WIPO initiative aims at recognizing communities for their innovations, and Farmers' Rights (a FAO initiative), specifically intended to recognize and compensate past, present and future work done by farmers, are far from fully operational.

OTHER CONSIDERATIONS

Indigenous seed practices are diverse, ingenious, and scientifically sound. A holistic study of such practices themselves, but also help to clarify the essence of the culture of peoples, including the use of certain plants, environments, animals and tools. While such knowledge would benefit sustainable agriculture, it could also be used against the local people, through the prevailing official -- but questionable -- development strategy and approaches.

There remains the gigantic job of documenting the many aspects of indigenous knowledge, with a view to promoting sustainable agriculture. The scientific basis of these practices may be of interest to researchers, but it must be remembered that practices may not work when they are removed form their socio-cultural and socio-ecological context. It must also be borne in mind that modern science has not yet fully explored all their possibilities and dimensions. In any case, these practices must be respected; they are not random processes, but rather products of the intellectual investigations of people who have had the opportunity to validate their practices for hundreds if not thousands of years.

When indigenous practices are found to be useful, it is everyone's moral duty to give credit where credit is due. Researchers and development workers should not immediately join in projects for the documentation of indigenous knowledge, as this cold eventually lead to the disempowerment of local people. It is important to investigate thoroughly how each project can best serve the community. Indigenous knowledge has a tremendous potential not only for sustainable but also for inequity.

In the study of indigenous practices, one must make an effort to understand both the scientific principles behind them and the environmental and socio-cultural context. The economic and political potential and implications of such practices must also be analyzed, to avoid a reductionist approach to problem solving. The seed, together with its associated uses and culture, is highly political and represents a source of dispute and rivalry within the field of global economics. The various considerations sketched above -- although they may appear overwhelming -- must be borne in mind by anyone who is truly dedicated to the cause of sustainable agriculture.

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INDIGENOUS SEED TECHNOLOGY AND NURSERY MANAGEMENT: THE RRDP EXPERIENCE

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INTRODUCTION

- A major component of RRDP Cycle II of the Department of Environment and Natural Resources (DENR) Rainfed Resources Development Project (RRDP) is the Regional Production Nurseries, Clonal Orchard and Species Trials Project, often referred to as "Clonal Nursery Project".

- The 3-year project was funded by the DENR and USAID and aimed to establish regional production nurseries, clonal orchard and species trials in the 7 different regional sites representing different sets of agroecological conditions.

- The UPLB Foundation Inc. (UPLBFI) was awarded the "Clonal Nursery Project" for a 3-year contract starting November 1988 until September 1991. This project was implemented in seven project sites identified by DENR as follows:

CAR	:	Busol Watershed, Baguio City
Region 3	:	Lourdes, Bamban, then Patling, Capas, Tarlac and Porac, Pampanga
Region 5	:	Napolidan, Lupi, Camarines Sur
Region 6	:	Tiolas, San Joaquin, Iloilo

Region 7	:	Lamao, Corte, Carmen, then Juanay, Manipis, Talisay, Cebu
Region 8	:	Nagaasan and Busay, Babatngon, Leyte
Region 10	:	Impalutao, Impasug-ong, Bukidnon

GOALS/TARGETS OF THE REGIONAL PRODUCTION NURSERIES

- The management of the 7 regional production nurseries involved two major goals/targets (Table 1).

1. Production/procurement of

a. 817,030 plantable seedlings of forest tree species and fruit/plantation crops for distribution by DENR to its regional projects;

b. 32,667 plantable seedlings, mostly forest tree species, for species trials, about 70% and 30% of which are plantable in planting season 1990 and 1991, respectively; and

c. 2,800 selected clones of fruit/plantation crops, about 80% and 20% of which are plantable in the clonal orchards in planting season 1990 and 1991, respectively.

2. Preparation and submission of a nursery manual on forest trees and fruit /plantation crops based mainly on the project experiences.

Table 1. Cumulative accomplishment in the 7 regional production nurseries (Nov. 1988-Sep. 1991).

REGION	Seedlings for Distribution by DENR			Seedlings for Species Trials			Clones for Clonal Orchards		
	Target (No.)	Accomplishment		Target (No.)	Accomplishment		Target (No.)	Accomplishment	
		No.	%		No.	%		No.	%
CAR		170,050		2,667	2,850	107	400	426	107
3		91,826		5,000	10,021	200	400	467	117
5		128,135		5,000	5,110	102	400	517	129
6		98,564		5,000	6,045	121	100	459	115
7		154,097		5,000	5,305	106	400	475	119
8		69,052		5,000	6,061	121	400	518	130
10		156,379		5,000	5,002	100	400	467	117
Total (No.)	817,030	869,103		32,667	40,394		2,800	3,329	
Average (%)			106			123			119

Table 2. Sowing techniques for some forest tree species and fruit plantation crops in 7 regional nurseries in the Philippines*

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
A. PLANTATION FRUIT AND CROPS						
1. Achuete	SDBX:B	1:3 StGsSa	1 x 0.5		92	R-6
	SDBD:R	1:4 UnGsCo	1.5 x 1		80	R-8
2. Anonas	DSPB	2:1 UnGsSa			60	R-6
3. Atis	SDBD:R	1:1 GsSa	2 x 2	SW 24	93	R-7
	SDBD:R	4:1 UnGsCo	1.5 x 1	SW 24	60	R-8
4. Avocado	DSPB	3:1 UnGsSa	Seed tipping upward		80	R-6
5. Balimbing	SDBD:B	4:1 GsCo		SW-24	90	R-8
6. Cacao	DSPB	2:1 GsSa			76	R-6
	SDBD:R	UsGs	2 x 2	SW-2	98	R-7
	SDBD:R	4:1 GsCo	2 x 1	SW-24	70	R-8
	SDBD:R	1:1 GsCo		SW-24	94	R-10
7. Calamandarin	SDBD:R	4:1GsCo	10 x 1	SW-24	100	R-8
8. Calamansi	SDBX:R	1:3 StGsSa	1.5 x 0.5	IS	92	R-6
	SDBX:R	1:3 StGsCo	1 x 2	SW-6	86	R-7
	SDBD:R	4:1 UnGsCo	1 x 1	SW-24	80	R-8
9. Camachile	SDBD:R	UnGs	2 x 2		80	R-7
10. Cashew	DSPB	3:1 GsCo		SW-24	80	R-3
	DSPB	2:1 GsSa			36	R-6
	DSPB	GsCo			73	R-6
11. Chico	SDBD:R	2:1 StGsSa	1 x 0.5		73	R-6
12. Mandarin/ Sintones	SDBD:R	4:1 GsCo	1 x 1	SW-24	83.3	R-8

HIGHLIGHTS OF ACCOMPLISHMENTS ON THE REGIONAL PRODUCTION NURSERIES

a. Planting Stock Production

- The cumulative accomplishments relative to goals/targets in the 7 regional production nurseries in terms of a) seedlings for distribution by DENR, b) seedlings for species trials, and c) clones for clonal orchards were 106%, 123%, and 119% respectively (Table 1).

b. Nursery Manual Preparation

- The experiences in the establishment of nursery and planting stock production practices for each species were documented by the 7 regional site managers. These were reviewed, analyzed and then consolidated by the Project Management Office (PMO) staff and consultants into a Nursery Manual on Forest and Fruit Species.

- The manual is divided into two parts. The first part is a documentation of nursery establishment procedures employed in the project. The second part is a detailed description of the nursery practices applied for each species.

- The manual covers 90 indigenous and exotic species/provenances/cultivars representing 62 forest trees and 28 fruit/plantation crops.

- The manual can be used as a guide for nurserymen especially in the propagation of many indigenous species whose silviculture is hitherto unknown.

NURSERY MANAGEMENT

Nursery Establishment

- The critical role of the site and the importance of proper site preparation and provision of facilities have been the primary concern of the project even during the planning for nursery establishment.

- Thus, considerable time and effort were devoted to site selection and characterization.

- Subsequent experiences in nursery establishment proved our early contention that much of the practices would depend on site specific conditions.

  1. Site Characterization

- The production nurseries were established in 7 sites: Baguio City in Cordillera Administrative Region; Bamban, Tarlac later transferred to Patling, Capas, in Region 3; Napolidan, Lupi, Camarines Sur in Region 5; Tiolas, San Joaquin, Iloilo in Region 6; Corte, Carmen, Cebu in Region 7; Naga-asan Babatngon, Leyte in Region 8; and Impalutao, Impasug-ong, Bukidnon in Region 10.

    a. Location

- The sites are within reforestation, timberland and A & D areas, national park, or in private land and accessible by foot trail or light vehicles.

b. Climate

- The seven regions represent four climatic types according to rainfall distribution. Camarines Sur (R-5) and Leyte (R-8) are located in eastern coastal regions whose long rainy season is suitable for extended planting and for crops which do not require a long period of dormancy in order to flower and bear fruit.

- Iloilo (R-6), Tarlac (R-3) and Baguio City (CAR) have more distinct wet and dry seasons suitable for mango, cashew and other drought tolerant perennial crops. Cebu (R-7) has no distinct wet and dry seasons but is relatively dry from November to April.

- Bukidnon has the best type of climate characterized by even distribution of rainfall which is highly suitable for the production of many fruit trees.

c. Soil

- The soils are clay to clay loam (CAR, R-5 and R-6), clay (R-8 and R-10) and silty loam (R-3).

- They have generally good internal and surface drainage because of their texture and slopes.

- Soil pH is acidic (CAR, R-5 and R-10), slightly acidic (R-8 and R-3) and basic (R-7).

- Soil fertility is fairly good in terms of organic matter to poor in terms of P and K.

d. Vegetation

- The vegetation includes forest and fruit species and some annual crops. The open areas are covered with shrubs and grasses.

- The nursery sites are flat (R-3, R-5 and R-6) to gently rolling (R-7, R-8, R-10 and CAR) and are usually beside or near the clonal orchard (R-5).

- They are near sources of water: Baguio Water District reservoir (CAR), Napolidan River (R-5), Tiolas River (R-6), a small creek (R-8) and Bacunayon Creek (R-10).

2. Site Preparation

- Slopes of rolling lands are terraced (CAR, R-7, R-8 and R-10) while those in the flat areas (R-3, R-5 and R-6) were just brushed and cleared.

- In Leyte, the nursery was established first in terraced plots at Naga-asan and moved later to a new nursery site at Busay.

- Bench terracing was done to flatten the slope, thereby allowing the area to accommodate one to two potbeds of seedlings and at the same time control erosion.

3. Construction of Nursery Facilities

a. Potting Shed

- This is a service facility intended to provide a good working condition for nursery utility workers who perform regular and important nursery practices, such as soil preparation and mixing, soil sterilization, plastic bag preparation, potting, re-potting, among others. Sometimes, this also serves as repository of nursery tools and supplies.

- Sheds were constructed using the most readily available and less expensive materials such as small logs for post, bamboo for roofing frame, and cogon for roofing.

b. Seedbeds

- Seedbeds were prepared on a suitable area, i.e. one with well-drained soil, near the source of water and near the potbeds.

- Seedbeds are usually 1 meter wide, a few meters long, and raised 10-20 cm from the ground.

- In Bukidnon and Iloilo, some seedbeds were prepared in elevated platforms (1 meter from the ground) and protected from rain and full sunlight by shade structures with overhead plastic roofing (R-6).

- These seedbeds were enclosed at the sides with bamboo splits to hold the soil in place and prevent it from being washed off during watering.

- Seedbeds in CAR were exposed to full sunlight while those in Tarlac, Leyte and Camarines Sur were covered with mat of bamboo slats, woven talahib stems, and coconut leaves, respectively.

- Seedboxes were also used. In Cebu, wooden cases of softdrinks and halved plastic water containers were used as seedboxes.

- The germination medium used differs in various locations. It was garden soil + compost in Region 10, garden soil + compost at 4:1 ratio in Region 8, garden soil + sand + powdered cow manure in Region 7, garden soil + sand at 1:1 ratio in Region 6, garden soil + sand at 3:1 ratio in Region 5, garden soil + compost at 3:1 ratio in Region 3, and topsoil in CAR.

c. Potbeds

- To ensure early seedling recovery, newly potted seedlings or those that were directly seeded in plastic bags were arranged on potbeds.

- Potbeds are usually one-meter wide, and a few meters long.

- They are provided with shade either by live trees or overhead structures made of ipil-ipil or poles, bamboo culms, or small logs as posts, bamboo as frames and coconut leaves for roofing.

- In Leyte, a removable shade structure built with woven mat of talahib stems as roofing and bamboo or tree stem as post were used.

- In Tarlac, partial shade was provided with removable woven mat of bamboo slats which were installed on a meter-high post in individual potbeds.

- In contrast, the shade structures constructed in Camarines sur and Iloilo were bigger and taller and provided shade on all potbeds.

- The seedlings have to be arranged properly to keep them together on the ground.

- This can also be accomplished by enclosing the potbeds with bamboo slats or dug them in the ground.

- Half-meter pathways were maintained between potbeds to make the seedlings easy to reach during fertilization, irrigation, and pest control.

d. Bunkhouse

- In all project sites, bunkhouses were constructed to serve as quarters for site managers and staff, and storehouse of various tools, equipment and supplies.

- They were constructed using the cheapest and most available materials from local sources such as small logs and bamboo for post, sawali for wallings and nipa or cogon leaves for roofing. They stood on stilts (R-6, R-7 and R-10) or were constructed like a bungalow (Region 5 and CAR).

e. Water Source and Irrigation Facilities

- If there is one thing which is considered the most important in the establishment and maintenance of a nursery, it is the source of water.

- Without it, it is difficult to carry out effectively nursery activities such as irrigation, fertilization, spraying, germination, scarification, and seed preparation, among other things.

- Water source is a basic information in site characterization and a very important matter to consider in site selection.

CAR - Water comes from the Baguio Water District reservoir, and is conveyed to the nursery using ½ inch polyvinyl pipe, and sprinklers are used for irrigation.

Region 3 - Water is tapped from underground source using a water pump (Jetmatic brand) installed at the old DENR building by DENR-CENRO Capas Refo/Impact Project and improved by UPLBFI. Hand sprinklers are used for irrigation.

Region 5 - The nearest source of water is a natural spring which is located about 100 m from the nursery. A holding concrete tank was installed near the spring. Water is conveyed (to the nursery) through polyvinyl pipes. Hand sprinklers and rubber hose are used for water distribution.

Region 6 - The Tiolas River beside the production nursery is the nearest source of water. Water is transported to the site using water pails. Watering is done using hand sprinklers.

Region 7 - Water is drawn from a nearby small creek. The walls of the creek were rip-rapped with stones and an empty oil drum was placed at the center of the creek as an improvised catchment basin. Attached at the bottom of the drum is a rubber hose which transports water to the nursery which is about 200 m away from the creek. Watering is done using hand sprinklers.

Region 8 - Water in the first nursery (Naga-asan) came from a nearby deepwell, tapped by water pails and distributed using hand sprinklers. In the second nursery (Busay), water comes from a nearby natural spring, tapped by using polyvinyl pipes and is distributed to the old FORI building in steel pipes. Watering is done using hand sprinklers.

Region 10 - Irrigation water is provided either by the nearby Bacunayon Creek or through a water pump (Jetmatic brand) installed in a strategic area with the nursery. Water is first stored in a holding water tank (usually a water drum). Watering is done using hand sprinklers.

f. Layout

- The layout of the physical structures in the nursery was designed to facilitate various nursery operations, e.g. germinating beds have to be adjacent to potting shed and the latter to the potbeds.

g. Tools and Equipment

- Basically, tools and equipment for seedbed preparation, germination, soil preparation, transplanting and seedling maintenance are provided for each site.

- The most commonly used tools and equipment include bolo, hoe, rake, spade, shovel, wheel barrow, pick mattock, weighing scale and sprayer (16 liters capacity).

- Two sites (R-3 and R-10) use water pump (Jetmatic) in the conveyance of water from the source to the nursery site.

Sourcing of Propagules

- Propagules of selected species to be raised for distribution to DENR Projects and for setting up species trials and clonal orchards were sourced locally, either collected from identified mother trees or purchased from accredited nurseries and seed suppliers.

- For example, seeds of many forest tree species were collected from selected trees from Mt. Makiling Forest Reserve while clones of selected fruit/plantation crops were procured from UPLB and Regional BPI nurseries as well as accredited private nurseries like Felzar Nursery in Mandawe City.

- Seeds of some fruit/plantation crops were also obtained from fruit vendors/retailers in the towns and cities of the country particularly those near the project sites.

Seed Handling

- Seeds collected/procured were packed in appropriate containers/ packages during seed transport from the source to the nursery site, stored and then subjected to pre-treatment, if necessary, prior to sowing.

- The methods and means/media used generally vary from species to species although some have similar treatments (Table 2).

1. Packages/Containers for Seed Transport

- Seeds should be properly packaged to ensure their good quality during transport from the source to the nursery site.

- Seeds were packaged in proper envelopes, plastic bags, and/or sacks.

- Most of the seeds of forest tree species and fruit/plantation crops were packed in polyethelene (plastic) bags.

- Only a few were packed in paper envelopes and sacks.

- Those packaged in plastic bags and paper envelopes are fine to medium sized seeds (such as agoho, ipil, ipil-ipil, bagras, atis, guayabano, suha) while those packaged in sacks are medium to large seeds (such as narra, mahogany, yemane, mabolo/kamagong, nangka, mango).

Table 2 Legend and Explanatory Notes

1. Method:	B	-	broadcast
	R	-	sowing in rows/drills
	SDBX	-	seedbox
	SDBD	-	seedbed
	DSPB	-	direct sowing in plastic bags
2. Media:	St	-	sterilized
	Un	-	unsterilized
	Gs	-	garden soil
	Sa	-	sand
	Co	-	compost
3. Spacing	Distance between rows and within rows		
4. Pre-sowing Treatment	IS	-	immediately sown (no treatment)
	SW-24	-	soaked in water for 24 hours
	HW	-	hot water treatment
	SCARI	-	scarification

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
13. Kape	SDBD	StGs		SW-24	81	CAR
	SDBD	3:1 GsSa	3 x 1		60	R-5
	SDBD	1:2 GsSa	2 x .5		1.2	R-6
	SDBD	GsCo	1 x 1	SW-24 (depulped)	89	R-7
	SDBD	4.1 GsCo	2 x 2	SW-24 (Depulped)	58.3	R-8
	SDBD	GsSa	3 x 2	SW-24 (Depulped)	74	R-10
14. Duhat	SDBD	2:1 UnGsS2	2 x 1		70	R-6
	SDBD	2:1 GsSa	2 x 2		70	R-7
15. Guayabano	SDBD:B	Gs			50	CAR
	SDBD:R	2:1 GsSa	5 x 1-2		80	R-3
16. Guava	SDBX	StGsCoSa	2 x 1	SW-12	98	R-7
17. Nangka	DSPB	3:1 GsCo		IS	80	R-3
	DSPB	1:2 SaGs		IS	80	R-5
	DSPB	1:2 SaGs		IS	63=97	R-6
	SDBD	GsSa	2 x 2	SW-12	80-95	R-7
	SDBD	4:1 GsCo	2 x 2	SW-24	50	R-8
	DSPB	GS		Sw-24	67	R-10

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
18. Kapok/ Bulak	SDBD	Gs	2 x 2	IS	87	R-7
19. Lipote	SDBD	2/3:1/3 GsSa	2 x 1	IS	70	R-5
20. Mabolo/ Kamagong	SDBD	3:1 UnGsSa	4 x 3	IS	97	R-5
	DSPB	2:1 UnGsSa		IS	88	R-6
21. Mangga/ Mango	SDBD	Gs	2 x 3	SW-6 dehusked	12-18	R-7
	SDBD	4:1 UnGsCo	3 x 1	SW-24 dehusked	50	R-8
22. Marang-banguhan, Marang	SDBD:R	2:1 GsSa			58	R-6
	SDBD:R	4:1 GsCo	2 x 1	SW-24	2.6	R-8
	SDBD	GsCo		SW-12	96	R-10

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
23. Pili	DSPB	3:1 GsCo		SW-36	85	R-3
	SDBD:R	2:1 GsSa	5 x 3	SW-16	80	R-5
	SDBD:R	StGsCo	3 x 2	SW-1/2	7.7	R-7
	SDBD:R	4:1 StGsCo	3 x 3	SW-24		R-8
	SDBD:R	StGsCo	10 x 5		49	R-10
24. Pomelo, Suha, Lukban	SDBD:R	4:1 GsCo	1 x 1	SW-24	67	R-8
	SDBD:R	GsCo	5 x 3	IS	96	R-10
25. Rambutan	SDBX:R	3:1 StGsSa	2 x 1		60	R-6
	SDBD:R	4:1 GsCo	1.5 x 1	SW-24	3	R-8
26. Santol	DSPB	2:1 GsSa	3 x 7		87	R-6
27. Caimito, Starapple	SDBD:R	4:1 GsCo	3 x 1		87	R-8
28. Tiesa	SDBD:R	GS	2 x 2		92	R-7
	DSPB	2:1 GsCo			98	R-6

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
B. FOREST TREE SPECIES						
1. Acacia Pera	DsPB	GsCo			31	R-10
	SDBD:R	Gs	5 x 1-2		70	R-3
2. African tulip		GsCo	5 x 1-2	SW-12	70	R-10
3. Agoho	SDBD:R	GsCo	5 x 1		99	R-10
	SDBD	Gs			86	CAR
	SDBD	Gs			0	R-3
	SDBX	GsCoSa			8	R-7
4. Akleng parang	SDBX	GsSa			22.5	R-8
5. Alibangbang	DSPB	Gs			75	R-6
6. Alnus	SDBD:R	GsSa	2 x 1		97	R-6
7. Alupag	SDBD:B	Gs			10	CAR
8. Amugis	SDBD:R	GsSa	2 x .5		49	R-6
	SDBD:R	GsSa	2 x 2		22	R-6
9. Anabiong	SDBD:R	Gs	2 x 2	SW-12	95	R-7
10. Antipolo	SDBX:R	GsSa	1 x 1	SW-6	64	R-7
	SDBD:R	Gs	2.5 x 1.5-2		70	R-3

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
	SDBD:R	2:1 GsSa	2.5 x 1.5-2		34	R-6
	SDBD:R	Gs	2.5 x 1.5-2	SW-12	12	R-7
11. Antsoan Dilaw	SDBD:R	GsSa	2-10 x 1		28	R-6
	SDBD:R	Gs	2-10 x 1	SW-12	95	R-7
12. Silk Tree	SDBD	Gs			70	CAR
13. Mimosa, Auri	SDBD:R	2:1 GsSa	1-3 x 1-5	HW	95	R-7
	DSPB	StGs		SW-12	59	R-10
14. Bagras	SDBX	GsSaCo		SW-8	88	R-7
15. Bahai	DSPB	GsCo		SW-12	18	R-7
	DSPB	GsCo			20	R-10
16. Balakat Gubat	SDBD:R	Gs	3 x 2	SW-12	11	R-7
17. Banaba	SDBD:R	GsCo	1.5 x 1.5	SW-24	71	R-8
18. Banuyo	SDBD	Gs			60	R-3
19. Benguet Pine	DSPB	Gs		SW-24	67	CAR
20. Bolon	SDBD:R	GsSa	2 x 1		20	R-8

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
21. Dao	SDBD:R	GsSa	1-3 x 1-2	SW-8	75	R-5
	SDBD:R	GsSa	1-3 x 1-2		55	R-6
	SDBD:R	GsSa	1-3 x 1-2	SW-12	8	R-7
22. Dungon late	SDBD:R	GsSa	5 x 3-5		73	R-6
	SDBD:R	GsSaCo	5 x 3-5		62	R-10
23. Earpod	SDBD:R	GsSa	2-10x2-5		68	R-6
	SDBD:R	GsCo	2-10x2-5	SW-12	35	R-10
24. Moluccan sau, Falcata	SDBD:R	GsSa			10	R-6
	DSPB	GsCo		SW-12	80	R-10
25. Fire tree	SDBD:R	GsSa	2-3 x 1-2	SCAR	62	R-5
	SDBD:R	Gs	2-3 x 1-2	SW-12	72	R-7
26. Gisok-gisok	DSPB	GsCo			33	R-10
27. Golden shower	SDBD:R	GsSa	2-5 x 1-2	HW	85	R-5
	SDBD:R	GsCo	2-5 x 1-2	SW-12	20	R-10
28. Igio	SDBD:R	GsSa	2 x 1		86	R-5
	SDBD:R	GsCo	2 x 1	SCAR + SW-48	88	R-8

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
29. Ilang-ilang	SDBD:R	Gs	2-4 x 1.2		60	R-3
	SDBX:R	GsSaCo	2-4 x 1-2	SW-10	97	R-7
30. Ipil	DSPB	GsCo		HW and SW-12	30	R-10
31. Kalantas	SDBD:R	Gs	1 x 1		92	R-3
32. Kalumpit	SDBD:R	GsSa	2-10x1-4		67	R-6
	SDBD:R	Gs	2-10x1-4	SW-12	78	R-7
	SDBD:R	GsCo	2-10x1-4		20	R-10
33. Kupang	SDBD:R	1:2GsSa	2-10x1-2		57	R-6
	SDBD:R	1:2 GsSa	2-10x1-2	SW-12	87	R-7
34. Lamio	SDBD:R	GsSa	2 x 1		39	R-8
35. Lanutan	SDBD:R	Gs	1 x 1	SW-12	76	R-7
36. Lingo-lingo	SDBD:R	GSSa	2-5x1-2		7	R-6
	SDBD:R	Gs	2-5x1-2	SW-12	10	R-7
37. Mahogany	SDBD:R	GsSa	2-5x1-2		52	R-5
	SDBD:R	Gs	2-5 x 1-2	SW-12	93	R-7
38. Mamalis	SDBX:R	GsCoSa	2 x 1	SW-6	85	R-7

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
39. Mangium	SDBD:R	Gs	.5-4 x1-2		70	R-3
	SDBD:R	GsSa	.5-4x1-2	SW-8	40	R-5
40. Molave	SDBD:R	GsSa	1-5x1-2		38	R-6
	SDBD:R	GsCo	1-5x1-2		30	R-10
41. Nalis	SDBD:R	GsCo	1-5 x 2		12	R-6
	SDBD:R	GsCo	1-5 x 2		80	R-8
42. Narra	SDBD	GsSa/GsCo	1-5x1-2	SW-12	53 to 94	All Regions
43. Neem	SDBD:R	GsSa	2-5 x 1-2		90	R-5
	SDBX:R	GsCo	2-5 x 1-2		20	R-10
44. Palawan Cherry	SDBD:R	GsSa	2 x 1	SW-48	8.6	R-6
45. Panglong-boien	SDBD:R	GsSa	2 x 1		80	R-5
46. Para rubber	SDBD:R	GsSa	3 x 2		80	R-6
47. Rain tree	SDBD:R	Gs	2-7x1-2	SW24	42	R-6
	SDBD:R	Gs	2-7x1-2	SW-24	99	R-10

Table 2 (Continued) ...

Species	Method	Media	Spacing	Pre-Sowing Treatment	Germination %	Regional Nursery Site
48. Red gum	SDBX:B	GsCo			67	R-6
49. Salago	SDBD:R	GsSa	2-4 x 2-5	SW-12	78	R-7
50. Spanish Cedar	SDBD:R	GsCoSa	2-10 x 1		90	R-5
	SDBD:R	GsCo	2-10 x 1		28	R-10
51. Supa	SDBD:R	GsSa	2-10x2-5	SCAR & HW	95	R-5
	SDBD:R	GsCo	2-10x2-5	SCAR & HW	22	R-10
52. Tanglin	SDBD	GsSa			45	R-6
53. Teak	SDBD:R	Gs	2 x 1	SW-36	12	R-7
54. Thailand Shower	SDBD:R	GsSa	2-10x1-3		78	R-6
	SDBD:R	GsCo	2-10x1-3		15	R-10
55. Yemane, Gmelina	SDBD:R	Gs	2-10x2-4	HW and SW-12		R-7
	SDBD:R	Gs	2-10x2-4	HW and SW-12		R-10

Table 3. Transplanting age, potting media, out planting/plantable age and height of seedlings of forest tree species and fruit/plantation crops in 7 regional nurseries.

Species	Transplanting Age After Germination (No. of days/Leaves)	Transplanting/Potting Media	Outplanting/Plantable	
			Age (Months)	Height (cm)
A. Fruit/Plantation Crops				
1. Achuete	21-42 days	1:3GsSa	4-5	40-45
2. Anonas		GsSa	5-6	65
3. Atis	30 days	4:1 GsCo	5-6	40-45
4. Avocado		GsSa	5-6	85
5. Balimbing		4:1 GsCo	4-5	35-40
6. Cacao	5-7 days	GsCo	5-6	30-40
7. Calamandarin	2 days	4:1 GsCo	5-6	20-35
8. Calamansi	14 days	GsCo	3-4	25-30
9. Cashew	3-4 leaves	GsCo	3-6	40-75
10. Chico	30-35 days	2:1 GsSa	6-7	70
11. Mandarin		4:1 GsCo	5-6	20-25
12. Coffee a) CAR	16-26 days 2-4 leaves	Gs	12	
b) Other Regions	16-26 days 2-4 leaves	GsSa	5-6	
13. Duhat	21-30 days	GsCo	6-7	70
14. Guyabano	15-45 days	GsSa	4-12	30-40
15. Nangka	3-6 days	GsCo	4-8	30-45
16. Lipote	10-14 days	2:1 GsSaCh<	4	28

Table 3 (Continued) ...

Species	Transplanting Age After Germination (No. of days/Leaves)	Transplanting/Potting Media	Outplanting/Plantable	
			Age (Months)	Height (cm)
17. Mabolo/Kamagong		2:1 GsSa	3-6	
18. Mango	5-10 days	GsCo	4-5	35-40
19. Marang-banguhan	12-16 days	GsCo	5-6	35-40
20. Pili	4-6 leaves	3:1 GsCo	4-7	
21. Suha/Lukban	5-10 days	3:1 GsCo	4-7	30-40
22. Rambutan	30-35 days	4:1 GsCo	8-9	
23. Santol	2 leaves	4:1 GsCo	3-6	
24. Caimito/Starapple	35-45 days	GsSa	6-7	70
25. Tiesa		GsCo	4-5	40-80
B. Forest Trees				
1. Acacia pera	16-20 days	Gs	4-5	35-40
2. African tulip	20 days	GsCo	6	
3. Agoho	20-42 days	GsSa/GsCo	5-7	50
4. Akleng parang		Gs	4-5	75
5. Alibangbang	14-21 days 2-3 leaves	Gs	4-5	60
6. Alnus	45 days	Gs	8	18
7. Alupag	21-28 days 3-4 leaves	GsSa	8-9	65

Nursery Practices

1. Soil Preparation

- Soil medium varied from one site to another but it was generally composed of fine sand, compost and garden soil in various proportions.

- Garden soil and compost were sourced around the nursery site; stony or pebbled soils were screened off to separate the finer particles.

- Soil and compost mixing was done thoroughly.

- The medium was generally used without sterilization. However, in the germination of some species, the soil was disinfected by baking and heating and treating with kerosene gas and pesticides. This medium was used for germination and growing of seedlings.

2. Sowing

- Seeds were germinated in seedbeds or seedboxes or sown directly in individual plastic bags (Table 2).

- Bigger seeds like cashew and avocado were directly sown while smaller ones were dibbled in the seedbeds.

3. Potting

- A few weeks after germination, seedlings were potted in individual plastic bags (Table 3).

- In some species and bare-root seedlings, root pruning was performed before transplanting.

4. Irrigation

- Irrigation was done regularly using hand sprinklers.

5. Weeding

- Regular weeding of seedbeds prior to sowing and during germination was practiced. It was also done in potted seedlings a few days after transplanting.

6. Pest Control

- Whenever necessary, protective sprays of insecticide and fungicide were practiced.

7. Hardening

- Prior to disposal all seedlings were hardened to prepare them to a change in growing environment when they were outplanted.

- They were gradually exposed to the sun by removing overhead shade and by gradual reduction of irrigation.

Table 3 (Continued) ...

Species	Transplanting Age After Germination (No. of days/Leaves)	Transplanting/Potting Media	Outplanting/Plantable	
			Age (Months)	Height (cm)
8. Amugis	9-70 days 2-4 leaves	GsCo	3-10	10-75
9. Antipolo	10-56 days	GsCo	4-9	15-75
10. Antsoan dilau	2-4 leaves	GsChM	4-6	25-50
11. Silk tree	30 days	Gs	8	25
12. Auri	8-30 days 3-6 leaves	GsSa	5-8	60-120
13. Bagras	14 days 4-6 leaves	GsChM		
14. Banaba	14 days	GsCo	5-6	35-40
15. Banuyo	30 days	GsCo	6	35-40
16. Benguet pine		Gs	8	18
17. Bolon	28-25 days	GsSa	7-8	75
18. Dao	10-35 days 3-5 leaves	GsChM	4-10	12-55
19. Dila-dila	35-45 days 3-5 leaves	GsSa	8-9	55

Table 3 (Continued) ...

Species	Transplanting Age After Germination (No. of days/Leaves)	Transplanting/Potting Media	Outplanting/Plantable	
			Age (Months)	Height (cm)
20. Dungon late	25-35 days	GsCo	6-9	19-85
21. Earpod	19-35 days 3-4 leaves	GsCo	6-9	75
22. Moluccan sau	21-28 days 3-4 leaves	GsCo	4-9	85
23. Fire tree	12-30 days 2-4 leaves	GsCo GsSa	3-6	25-31
24. Gisok-gisok	10-20 days 2-4 leaves	GSCo	4-8	11
25. Golden shower	15-49 days 2-3 leaves	GsCo GsCm	5-9	30-60
26. Igio	8-10 days 2-4 leaves	GsCo	5-6	30-40
27. Ilang-ilang	14-35 days	GsCo/GsSa/GsCm	6-7	40-80
28. Ipil		GsCo	8	
29. Ipil-ipil	10 days	GsCo	3	
30. Kakawate	10 days	Gs	5	
31. Kalantas	55 days	Gs	4	20-25
32. Kalumpit	15-42 days 3-4 leaves	GsSa/GsCo/GsCm	6-9	75

Table 3 (Continued) ...

Species	Transplanting Age After Germination (No. of days/Leaves)	Transplanting/Potting Media	Outplanting/Plantable	
			Age (Months)	Height (cm)
33. Kamiring	70-84 days 3-6 leaves	GsSa	9-10	75
34. Kupang	5-37 days 3-4 leaves	GsSa/GsCo/GsCm	4-9	12-75
35. Lamio	28-35 days	GsSa	7-8	70
36. Lanete	70-84 days 3-6 leaves	GsSa	9-10	75
37. Lingo-lingo	10-35 days 2-3 leaves	GsSa/GsCm	8-9	60
38. Mahogany	2-14 days 2-6 leaves	GsSa/GsCo/GsCm	5-7	35-75
39. Mangium	9-20 days 2-4 leaves	GsSa/GsCo/GsChM	5-6	33-40
40. Molave	10-28 days 4 leaves	Gs/GsCo/GsCm	5-6	75
41. Nalis	30 days 3-4 leaves	GsSa GsCo	5-6	
42. Narra	14-30 days 2-4 leaves	GsCm GsChM	6-10	35-85

Table 3 (Continued) ...

Species	Transplanting Age After Germination (No. of days/Leaves)	Transplanting/Potting Media	Outplanting/Plantable	
			Age (Months)	Height (cm)
43. Neem	12-35 days 2-4 leaves	GsSa GsChM	5-8	35-65
44. Palawan	21-28 days	GsSa	7-9	50
45. Panglongboien	15-42 days 2-6 leaves	GsSa	8-10	50-65
46. Para rubber	21-28 days 3-4 leaves	GsSa	6-7	75
47. Rain tree	10-30 days	GsSa/GsCM/GsChM	3-7	35-75
48. Red gum	21-28 days 3-4 leaves	Gs	6-7	60
49. Salago	20 days	Gs	8	
50. Spanish cedar	12-16 days 2-4 leaves	GsSa GsCo	4-9	30-65
51. Supa	28-35 days 2-6 leaves	Gs/GsSa GsCo/GsCm	5-11	20-75
52. Talitan	28-35 days 3-5 leaves	GsSa	7-8	65
53. Tanglin	21-28 days 3-4 leaves	GsSa	6-7	75
54. Teak	15 days	GsCm		
55. Thailand shower	15-42 days	GsCo	6-10	65
56. Yemane/Gmelina	15-20 days 2-4 leaves	GsCo GsCm	3-5	35-75

LESSONS LEARNED IN NURSERY MANAGEMENT

1. It is possible to set up production nurseries in privately owned land for government project, provided the terms of coordination and cooperation are clearly understood and properly documented.

2. Selection of suitable species to raise in the nursery for the DENR Regional Office projects was facilitated through consultations between the project staff and DENR officials. High preference was given to indigenous forest tree species for reforestation purposes while commercially important cultivars of fruit plantation crops for agroforestry purposes.

3. Difficult and costly procurement of seeds particularly indigenous forest tree species is one of the main bottlenecks in seedling production due to scarcity or remoteness of mother trees, seed-off year, or destruction of mother trees by typhoon, insects or illegal means.

4. Assurance of good seed viability by seed supplier is not enough. Nursery staff must also conduct seed viability testing before procuring large amount of seeds in order to insure that money and efforts are not wasted and commitments are met.

5. Several thousands of plantable seedlings have overgrown in most of the 7 regional nurseries because these were not picked up and distributed by DENR field offices. This problem was attributed to inadequate transport facilities to haul the seedlings and/or lack of coordination among the DENR concerned officials and project supervisors.

6. Emphasis on propagating indigenous forest and fruit tree species has provided opportunities for the generation of new nursery techniques for some species. These new nursery experiences were monitored, assessed and documented into a "Nursery Manual for Forest and Fruit Species" by the project.

CONCLUDING REMARKS

- The RRDP experiences on nursery establishment, seed handling and propagation techniques reveal that there are varied capabilities available from different regional nurseries which could be tapped towards successful production of planting stocks of indigenous and exotic forest tree species and fruit/plantation crops.

- However, refinements of these techniques for some species are needed to ensure higher effectiveness and efficiency in planting stock production.

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APPLICATION OF BIOTECHNOLOGY ON NURSERY MANAGEMENT

SOME REALITIES

- In agroforestry, harvesting of short season crops can gradually deplete a particular soil especially of its nitrogen element if recycling is not made possible through the use of nitrogen-fixing legumes.

- While inorganic amendment such as NPK is a common practice to replenish the lost elements, this does not bring back the other lost elements removed by harvesting.

- There are 13 elements needed by plants for growth aside from N, O, and C which are made available to plants free from the atmosphere.

- Tracer studies conducted on the efficiency of N fertilizers showed that of the total N fertilizer applied to the soils, only 23-53% are recovered or absorbed by the crops while the others are lost through volatilization, denitrification and leaching.

- There are other forms of N fertilizers other than urea and ammonium sulfate i. e. osmokote, multikote and sulfur-coated urea, but these are several times more expensive than the ordinary types found in the market.

- The application of inorganic fertilizer especially N is often not sufficient especially in the humid tropics where soils are generally more fragile. It is recognized that an important component in soil sustainability is organic matter.

- A continuous use of chemical N fertilizers especially in agricultural and agroforest areas have gradually contributed to a lowering in soil pH and consequently have rendered the fixing or immobilization of P.

- Grasslands such as those in Carranglan and Pantabangan, Nueva Ecija have low pH, i.e. pH of 4.0 - 5.5 and have 200-300 ppm total P but with only 2-5 ppm available or soluble P.

- To make the P available in soil conditions such as this, correction of pH either through liming or organic matter amendment becomes necessary.

- Another strategy is the application of mycorrhizal fungi to mobilize the bound elements and other nutrients.

- Mycorrhizal fungi have also been recognized to aid in water absorption, disease control, and indirect plant growth regulation through production of hormones and enzymes.

BIOLOGICAL NITROGEN FIXATION (RHIZOBIUM)

Mercedes U. Garcia

- Biological Nitrogen Fixation (BNF) is a process whereby atmospheric nitrogen (N_2) is converted to a form available to plants through the action of certain species of bacteria, blue-green algae and actinomycetes.

  - BNF in forestry and agroforestry is one and perhaps the most practical way by which the element nitrogen can be supplied. This can be utilized through interplanting a nodulated legume and a non-legume, alley cropping or crop rotation of a legume and non-legume or through enhancement of the population of the native free-living nitrogen fixers, or organisms associated with roots of plants or those symbiotically associated with non-legumes (e.g. Casuarina and Alnus). The legume-Rhizobium symbiosis and the Alnus and Casuarina-Frankia association are considered to be the most important to forestry especially in nursery and plantation establishment.

  - BNF is shown in this equation:

$$\mathbf{N_2 + 3H_2O\ (liquid)\ \text{-------->}\ 2NH3\ (aqueous) + 3/2\ O_2}$$

- The equation is simple but the process is complex and therefore will not be discussed in this paper.

- The legume family has a total of 16,000 species with the subfamily Mimosoideae having the most nodulated species *Parkia roxburghii, Cassia spectabilis, Tamarindus indicus*, and *Cynometra minutiflora* are leguminous but are non-nodulating.

- The soil harbors a vast population of microorganisms, both beneficial and harmful and they interact to compete for their nourishment and survival.

- The nitrogen-fixing organisms are also present in the soil, and their population depending on their requirements for growth could be increased by the presence of specific host plants (i.e. legumes in the case of Rhizobiun, or non-legume such as Alnus or Casuarina in the case of the actinomycete Frankia).

- The population and nitrogen-fixing activities of other species could be enhanced by the leachates of trees such as pines.

- The free living nitrogen fixers can perform fixation of atmospheric nitrogen with just the mere presence of carbon substrates provided by dead organic matter.

- Through intensive research and development of specific Rhizobium bacteria , inoculants for legume trees such as *Pterocarpus indicus, Acacia mangium, A. auriculaeformis, Samanea saman, Paraserianthes falcataria, Albizia procera, Sesbania grandiflora*, and *Gliricidia sepium* have been made available.

- Inoculation of either the seeds or roots of seedlings has been shown to improve growth and survival of the legume plant.

- The efficiency of the inoculant in terms of nodulating ability and consequently initial growth has been shown to be improved through phosphorus fertilization or combined inoculation with mycorrhizal fungi.

- The addition of modest amount of nitrogen fertilizer (i.e. 50kg N/ha or a slight adjustment of pH (i. e. pH 4.0 to 6.0) has proved effective in the early establishment of the symbiosis.

HOW IS RHIZOBIUM INOCULANT USED?

- When processing Rhizobium inoculants the target host plant should be considered so that the effect of the inoculant is assured.

- Specific inoculant preparation should be obtained, i.e. inoculant for soybean cannot be used for peanut or Ipil-ipil or Narra.

- The inoculant is usually supplied in solid form and packed in small plastic packets of 200 grams. It could also be supplied in liquid form and is usually applied by dipping the roots of seedlings or soaking the seeds in the culture for an hour prior to sowing.

- The solid inoculant is either applied as a seed or soil inoculant.

- As seed inoculant, the powder is either prepared as a slurry where the seeds are dropped and are mixed thoroughly until completely coated, or by plain dusting to the moist seeds prior to sowing. In the case of soil inoculant, the inoculant is applied directly to the soil or hole before the seeds are drilled or sown.

- Before any attempt to secure or use Rhizobium inoculant, it is important to conduct preliminary survey for nodulation of similar or related species in the area to be planted or reforested.

- If the plants are healthy looking and well nodulated, the use of introduced rhizobia may not be necessary.

- To indirectly determine whether the rhizobia in the nodules are effective or not slice the nodules and examine whether the inner tissues of the nodules are pinkish in color.

- This however does not guarantee that the native rhizobia are more effective than the strain to be introduced.

- A sure way of determining the need to inoculate is to conduct a snappy pot experiment using soil from the target site and subjecting the plants to the following treatments:

  T1 = -N uninoculated
  T2 = +N uninoculated
  T3 = -N inoculated

- Nodulation and total dry weight are two of the parameters used by lay personnel to assess the response to inoculation. More direct ways of assessing the effect of inoculation are: 1) measurement of N- uptake by plant, and 2) through N^{15} tracer technique. The data from the treatments may be compared and interpreted.

- If the T3 plants have better nodulation and are more vigorous than the T1 plants or as good as the T2 plants, then inoculation is effective and therefore necessary. If the T1 plants are as good as T2 and T3 plants, the introduction of rhizobia may not be necessary since this suggests that the native ones can support the nitrogen requirement of the host legume. In cases where the plants are stunted even if there are pinkish nodules, other nutrient deficiencies may be operating and tissue ans soil analyses become necessary to determine the deficient element.

- Similar approach to determining the need to inoculate may be used for Casuarina or Alnus-Frankia system.

- In the absence of commercially available inoculant for these species, nodules may be collected from healthy trees, washed, crushed and suspended in water and used to inoculate the seedbeds but caution should be exercised to make sure that there are no nematode-infected roots.

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TRICHODERMA TECHNOLOGY

Virginia G. Cuevas

STEPS IN PRODUCING PELLET CFA*

Materials:

For Pellet Production

- 1st class wheat flour
- 1st class rice bran

For sterilization and inoculation

- polypropylene bags (10" x 18")
- rubber bands
- sterile pipettes
- sterile water
- inoculating loop
- Prepared culture of Trichoderma
- alcohol lamp

Equipment needed:

- pressure cooker
- electric stove
- pelletizer machine or meat grinder

**modified from Camagun, C. J. R. and D. B. Lapis. 1993. Note: Practical approach in mass production of Trichoderma spp. as means of biological control against sheath blight of rice. Phil. Agr. 76(3):251-257*

Methods:

1. Sieve the rice bran. Make sure that there are no weevils (bukbok) present. As much as possible, the rice bran should be of good quality and newly produced. Old-stock rice bran carries a lot of microbial contamination.

2. The ratios of the ingredients are as follows: 1 kg rice bran: 300 g wheat flour: 400-500 ml water.

3. Combine all the dry ingredients and then add water. Mix thoroughly again.

4. Mix and knead the mixture by hand until a dough-like consistency is achieved.

5. Tear the dough into smaller lumps (about the same size as pan de sal). Turn on the pelletizer and push the lumps one by one into the mouth of the machine. The dough will come out as long, sticky strands (spaghetti-like).

6. Knead the strands manually so that they will be cut into 1-2 cm pellets.

7. Spread the pellets on a clean, flat surface and air dry for 15 minutes.

8. Place 500 g pellets per polypropylene bag. Secure the opening of the bag with rubber band.

9. Arrange the polypropylene bags with the pellets inside the pressure cooker. Sterilize the pellets for one hour at 15 psi.

10. Remove the packed pellets from the pressure cooker and allow them to cool.

11. After cooling, the pellets are ready for inoculation with Trichoderma.

Important Precaution:

Schedule your preparation such that you have a straight 2-3 hours work time.

- When you start preparing the rice bran pellet, you should make sure that you have enough time to finish these steps until sterilization.
- Rice bran is a very rich medium and once it is moistened, activity of the microorganisms cannot be stopped.
- It is important that you stop only after the pellets are already sterilized.

Inoculation Procedure

Make sure again that you have about 1-2 straight working hours.

1. Prepare a good culture of Trichoderma. It is best to use a 7-10 days old culture.
2. Add about 30-40 ml sterile water. The amount of water actually depends on the kind of culture vessel you have. If it is a flat rhum bottle, 30 ml sterile water is good enough. More water may be added after the initial amount have been used up.
3. Using sterile inoculation loop, scrape the spores and mycelia of the Trichoderma and let them be suspended in water.
4. Spread the sterile pellets in the polypropylene bags and place them in the inoculating table. Remove the rubber band from each bag without necessarily opening the bag.

5. By means of sterile 10 ml pipette, get 5-10 ml of the spore suspension and inoculate it to the sterile pellets. Make sure you spread the inoculant.

6. Inoculate the bags all at the same time. After inoculation, mix thoroughly the pellets to spread the inoculant. Three kg of rice bran plus needed wheat flour and water can make 5 kg pellets. Three flat rhum cultures of Trichoderma with about 100 ml sterile water were used to inoculate these pellets.

Always observe aseptic techniques.

7. After all the bags have been inoculated, put back the rubber band on each bag. Place the bags in a clean, dry shelf where there is minimum disturbance for incubation. Try to spread the pellets on the bag while in the shelf.

8. Caution. Ants, cockroaches and mice like to feed on the rice bran pellets. Make sure these animals are kept away from the incubation area.

9. There will be good growth of the fungus on the pellets. It will start as white mycelia on the 3rd-4th day and then will later turn green in one week time.

10. The pellets carry more than twice as much inoculum as the sawdust carrier. Therefore, the rate of inoculation to the substrate in composting will be reduced by half compared to the sawdust carrier.

Advantages of the pellets CFA:

1. In areas where sawdust is scarce, ricebran is a good substitute
.
2. All materials are readily available, but a little more expensive. Wheat flour can be bought from bakeries on per kg basis. Do not buy expensive brand.

3. You have better growth of the fungus since ricebran is richer in nutrients than sawdust. The inoculating value is higher. The volume of the CFA needed for composting can be reduced accordingly.

4. The pellet CFA is more presentable to the consumers. It is also more consumer-friendly.

Disadvantages:

1. There is a need to select good quality rice bran. Poor quality materials like those heavily infested with weevils will give problems of contamination.

2. Sterilization of the rice bran should be done properly, otherwise there will be plenty of contamination.

3. Pellet CFA is more expensive and is dependent on the pelletizing machine.

II. LIQUID CFA

Materials Needed:

- Fresh coconut water or potato tubers or Rice bran of good quality and calcium nitrate
- Fresh agar cultures of Trichoderma
- Clean flat rhum bottles or petri dishes
- Inoculating loop
- Alcohol lamp
- Cotton plugs

Equipment Needed

- Pressure Cooker or Sterilizer

There are three culture media that can be easily prepared for this type of CFA.

1. Sterile Coconut Water

   - Distribute fresh coconut water in flat rhum bottles about 50 ml per bottle.
   - Cover bottles with cotton plugs.
   - Sterilize for 15 minutes at 15 psi.
   - Cool and inoculate with Trichoderma.
   - Incubate the bottles lying on the flat side with the opening slightly raised.

2. Potato Dextrose Broth

   - Boil 200 g potato cubes until cooked in 1 liter of water, then sieve in clean, cotton cloth.
   - Dissolve 20 g glucose in 1 liter of potato extract.
   - Distribute the potato extract with glucose in flat rhum bottles -- about 50 ml per bottle.
   - Cover bottles with cotton plugs.
   - Sterilize for 15 minutes at 15 psi.
   - Cool and inoculate with Trichoderma.
   - Incubate the bottles lying on the flat side with the opening slightly raised.

3. Rice bran - Calcium nitrate medium

   - Boil 44 g rice bran in 1 liter water until rice is cooked.
   - Sieve the suspension in cotton cloth or in plastic mess to separate the bran from the liquid portion of the mixture.
   - Volume to 1 liter the collected supernatant.
   - Dissolve 8 g of Ca(NO3)2 in the collected supernatant.
   - Distribute the medium in flat rhum bottles -- 50 ml per bottle and cover bottles with cotton plugs.
   - Sterilize for 15 minutes at 15 psi.
   - Cool and inoculate with Trichoderma.
   - Incubate the bottles lying on the flat side with the opening slightly raised.

Harvesting:

1. After one week to 10 days incubation, harvest the floating mycelia. Scrape all the spores adhering on the sides of the culture bottles.

2. Collect all mycelia from the bottles utilized in 1 liter prepared medium. The culture medium from where the organism grows may be included.

3. Suspend these mycelia/spores in 10 liters of water. Mix thoroughly using a wooden stirring rod.

4. Use the spore and mycelial suspension for composting 2-3 tons of substrates.

Advantages of using liquid CFA:

1. Liquid CFA is easy to prepare. Time needed for preparation is very short. Incubation period is only 1 week to 10 days.

2. Materials needed are very cheap. The only equipment is the pressure cooker.

3. It is very easy to use.

Disadvantages:

1. Liquid CFA cannot be stored. The life span of the CFA is only 24 hours.

2. Preparation of the CFA must be timed such that it will be used for composting at the end of the incubation period of the organism.

Table 7. Some Important chemical and physical properties of soil after varying number of seasons compost was applied by the farmer cooperator. (Dates enclosed in parenthesis are the dates samples were taken).

Treatment Code	Number of Seasons Compost was Applied		PH		% Organic Matter		Bulk Density	CO2 Evolved (mg/d dry soil)
	At the start (Oct. 91)	At the time of sampling (Mar. 93)	At the start (Oct. 91)	At the time of sampling (Mar. 93)	At the start (Oct. 91)	At the time of sampling (Mar. 93)		
T1	1	2	5.3 ab	6.0 b	1.6 a	2.2 c	1.1 a	2.2 b
T2	2	4	5.3 ab	6.0 b	1.7 a	2.8 b	1.1 a	3.5 ab
T3	4	6	5.5 ab	6.1 b	1.2 a	3.2 ab	1.2 a	3.4 a
T4	6	8	6.0 a	6.9 a	1.0 a	3.6 a	1.2 a	2.4 b
T5	none	none	5.2 b	5.6 b	0.7 a	1.5 b	1.0 b	3.8 a

Note:

Each figure is an average of 3 replicates. Means followed by the same letter are not significantly different by DMRT at 5% level of significance.