SCIENTIFIC WEEK

Tropical Agriculture Research and Higher Education Center

RESEARCH ON

SUSTAINABLE TROPICAL AGRICULTURE AND INTEGRATED NATURAL RESOURCE MANAGEMENT PROGRAMS

Selected Papers of the Scientific Week,
held at Turrialba,
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Rodolfo Salazar
Editor

PREFACE

The Tropical Agronomical Research and Higher Education Center (CATIE) is a regional organization with more than 20 years supporting its member countries through research and higher education framed within its Programs Sustainable Tropical Agriculture, Integrated Management of Natural Resources and Education for Development and Conservation, to improve the well-being of the population in the American Tropics.

CATIE, located at Turrialba, Costa Rica, is economically supported by more than 40 countries and international organizations. Research works are conducted in the headquarters as well as in the member countries, in which more than 200 professionals and M.Sc. students participate. Research is focused on solving the main constraints to agriculture, forestry and rational management of natural resources. To intensify dissemination mechanisms of the results obtained is crucial to reached the objectives stated, through research and education.

In this institutional forum, the results of 95 research works, 63 from the Program in Sustainable Tropical Agriculture and 33 from the Integrated Management of Natural Resources Program, were presented. Extended summaries of these results were published in two Spanish volumes. This English version includes the summaries of the most relevant papers of both programs.

If additional information on the summaries included in this volume is required, please feel free to request the complete document to the author at CATIE.

Organizing Committee

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Dr. Pedro Ferreira
Dr. Glenn Galloway
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WORDS BY DIRECTOR GENERAL

Dr. Rubén Guevara

Several axioms exist about research. In the context of CATIE's Scientific Week two are very relevant: Publish or perish and publish with prior revision by scientific colleagues.

The significance of these axioms goes beyond the simple act of publishing; it also implicates report, transfer and extension of research results scientific and technological validation and adaptation to the general public. There is also a strong need to submit results to the scientific community for revision and verification of solidness based on scientific method.

The Scientific Week is a forum where the Center's scientists present their results of research, validation and transfer, with the objective of reporting and submitting these results to the analytic considerations of colleagues. It is expected that these results will be published and transferred to the Tropical American countries as soon as possible.

This process offers the opportunity to evaluate research at CATIE and to relate it to the general development of our countries.

Hopefully, the Scientific Week will welcomed by researchers and professors at CATIE, from other institutions, producers, governmental authorities of the countries and by the international community. We are confident that those involved will help make CATIE more influenced and powerful in the development of our region.Esa es nuestra meta, nuestro deber y nuestra obligación.

SUSTAINABLE TROPICAL AGRICULTURE PROGRAM

SUSTAINABLE TROPICAL AGRICULTURE PROGRAM (PATS)

Dr. Joseph Saunders, Program Director

The present Sustainable Tropical Agriculture program was formed by uniting the two prior programs of Annual Crops and Perennial Crops. The three areas of the Program (Tropical Crops, Plant Protection and Agroforestry Systems), together with other CATIE's Programs, constitute an entity for the development of sustainable production systems.

CATIE has established the Tropical Crops Area in order to continue the research for technological options that will help farmers to improve crops productivity while promoting sustainablility actions. The Tropical Crops Area (composed by the Crop Management, Phytogenetic Resources and Biotechnology Units) will develop research, validation and technology transfer activities using an Integrated Production System Approach, which the farmer and his family are the most important group entity within the scheme technology development and biodiversity conservation scheme.

Phytogentic resources are the strategic component that allows CATIE to execute its mandates to conserve biodiversity and to promote the development of agricultural systems. Biotechnology techniques applied to agriculture and natural resources, include plant tissue culture, molecular biology and genetic engineering. The Plant Protection Area has employed, since 1984, the philosophy of Integrated Pest Management, in roder to conduct research and outreach activitie. Biological and cultural control alternatives have been developed, as well as recommendations to rotate the use of pesticides in order to control insects, diseases, nematodes, and weeds of regional economic importance.

The Agroforestry Area has interdisciplinary and integration functions. This Unit, together with the Annual and Perennial Crops consolidate existing agroforestry systems (coffee, shaded cocoa, and taungya) and generates new ones (annual food crops, support systems) through long-term research, both at experiment stations and on-farm sites. The Agroforestry unit's Livestock Area considers animals as part of the socioeconomical and ecological reality.

CHANGES IN SOIL PROPERTIES IN LONG-TERM AGROFORESTRY EXPERIMENTS IN COSTA RICA

Donald L. Kass, Hans Fassbender,
Pedro Oñoro, Jorge Jiménez

RESUMEN. Se resumen los efectos sobre las propiedades del suelo, los cuales han sido observados en cuatro experimentos agroforestales a largo plazo realizados en el Centro Agronómico Tropical de Investigación y Enseñanza (CATIE) en Turrialba, Costa Rica. Los experimentos fueron 1) cacao, café, y pastos con una leguminosa (Erythrina poeppigiana (Walp.) O.F. Cook y un árbol de sombra no leguminoso (Cordia alliodora); 2) café con y sin sombra de E. poeppigiana a diferentes niveles de fertilización; 3) una rotación maíz-frijol con diferentes enmiendas orgánicas incluyendo agricultura en callejones con E. poeppigiana y Gliricidia sepium (Jacq.) Walp; y 4) maíz continuo con E. poeppigiana a diferentes espaciamientos.

Long-term experiments are especially necessary for agroforestry systems research where the effects of trees on soil properties are likely to take several years to express themselves and where evaluation of the sustainability of the systems is sought. In this paper the effects on soil properties observed in four long-term experiments: 1) cacao, coffee, and pastures with a leguminous (Erythrina poeppigiana (Walp.) O.F. Cook and non-leguminous (Cordia alliodora) shade tree; 2) coffee with and without shade of E. poeppigiana at different fertilizer levels; 3) a maize-bean rotation with different organic amendments including alley farming with E. poeppigiana and Gliricidia sepium (Jacq.) Walp.; and 4) continuous maize with E. poeppigiana at different spacings are summarized.

All these experiments were set up more than nine years ago and data on soil analyses at the beginning and later on in their development is available.

In the first experiment, an increase was observed in organic matter in both systems with cacao. Nutrient losses due to leaching were low in both systems, similar to natural forests situation, but Ca and Mg losses were higher for Erythrina than for Cordia. In both systems, soil K and Ca losses and increases in Mg content were observed (Fassbender, 1993).

In the second experiment, shaded plots showed higher levels of exchangeable Ca, Mg, and K than unshaded ones (Table 1). Differences in available phosphorus between shaded and unshaded were not observed.

Table 1. Soil nutrient status of plots of shaded (+S) and unshaded (-S) coffee, after seven years in Turrialba, Costa Rica.

	pH		Exchangable Acidity		Ca		K		Mg		P	
	-S	+S	-S	+S	-S	+S	-S	+S	-S	+S	-S	+S
	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1	cmol kg-1
No fertilization	6.0	6.2	2.00	1.40	5.5	9.0	0.62	1.23	1.3	2.0	30	36
66 kg/ha/year N 10 Kg/ha/year P 32 Kg/ha/year K	6.0	6.2	1.50	0.30	6.0	9.5	0.76	1.18	1.2	2.0	63	28
132 Kg/ha/year N 20 Kg/ha/year P 64 Kg/ha/year K	5.9	6.2	2.03	0.25	5.0	10.0	0.44	1.05	1.2	2.1	51	39
198 Kg/ha/year N 30 Kg/ha/year P 96 Kg/ha/year K	6.4	6.1	0.30	0.40	10.5	9.0	1.00	1.27	1.5	2.0	29	39
264 Kg/ha/year N 40 Kg/ha/year P 128 Kg/ha/year K	6.0	6.1	1.70	0.40	5.0	8.0	1.11	0.98	1.4	2.0	36	37
250 Kg/ha/year N	6.0	5.8	1.30	1.20	7.0	6.5	0.77	0.91	1.3	1.5	32	45

Table 2. Crops and weed nitrogen uptake for nine months gN m-2 in Turrialba.

	Weeds	Weeds	Maize	Weeds	Beans	Total	N mulch applied	%N effic. [N uptake / N applied]
Days after mulch application	50	105	110	245	265			
Erythrina in alley cropping	0.274	0.209	1.114	0.106	0.097	1.800	15.29	11.8
Gliricidia in alley cropping	0.324	0.447	1.422	0.274	0.091	9.46	9.46	27.0
Control with crop residues	0.282	0.177	0.212	0.219	0.042	0.932	4.97	18.8

In the third experiment, potassium content in the soil increased with all amendments and with alley cropping. Available phosphorus in the soil decreased in some degree with alley cropping. Changes in nitrogen and organic matter contents in the soil were almost non existent in all treatments. Increases in bean production with amendments may be due to improvement of the soil physical properties, including retained water during the dry season.

An increase in total C and N, microbial C and N, water soluble C in the treatments of alley cropping was observed, but C and N levels in microbial biomass were low for all treatments.

Very few (less than 15%) of N in pruned material in alley cropping treatments was taken up by the crop to which it was applied. Even less was taken up by the following crop, indicating that most N is either leached, incorporated in the organic matter or re-absorved by the trees (Table 2). Addition of amendments increased inorganic P levels in the soil, but additions of amendments without mineral P decreased labile and moderately labile organic P.

In the fourth experiment, a decrease was observed in all nutriments levels in the soil over time, except for available P (Olsen) which increased. The difference may be due to the original vegetation of the site which was forest.

There is evidence of recycling of the soil cations in the different agroforestry systems. Identification of changes in C, N, and P require more sophisticated techniques than the routine laboratory procedures commonly used.

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MICROENVIRONMENT, NUMBER OF SPORES IN THE AIR AND INCIDENCE OF Moniliophthora roreri CIF & PAR. EVANS ET AL. UNDER THREE LEGUMINOUS SHADE MANAGEMENT SYSTEMS IN CACAO (Theobroma cacao)

Luis Meléndez

RESUMEN. La temperatura, la humedad relativa, el número de esporas de monilia y la incidencia en plantaciones de cacao con sombra de una de tres especies de árboles leguminosos (Erythrina poeppigiana, Gliricidia sepium e Inga edulis) fueron estudiados en las tierras bajas húmedas en el Atlántico de Costa Rica, entre Diciembre, 1992 y Mayo 1993. No se econtraron diferencias significantivas entre las especies de sombra en términos de temperatura ambiental, humedad relativa e incidencia de monilia, podredumbre de la vaina. Hubo mucho más esporas bajo sombra de poró y se encontraron diferencias temporales en el número de esporas de monilia.

A study was conducted on microenvironment, spore populations and "monilia" incidence, between December 1992 and May 1993 in Margarita, Limón, Costa Rica.

The study consisted of 3 agroforestry systems: cacao (Theobroma cacao) in association with different leguminous shade trees: poró (Erythrina poeppigiana), madero negro (Gliricidia sepium) and guava (Inga edulis) with six interclonal cacao crossbreedings: "UF 676 X IMC67," "POUND7 X UF668," "UF613 X IMC67," "UF613 X POUND12," UF29 X UF613," "CATONGO X POUND12." A completly randomized block design, with a divided plot arrangement was used where interclonal crossbreeding corresponds to the small plot and shade species to the large plot.

A hygrothermographer was installed under each shade tree for microclimate mesurements. From the data obtained, daily temperature and relative humidity averages were calculted over time, for each shade; as well as rainfall near the plantation.

Fixed cylinder traps were used to count spores. Two kinds of samplings were conducted: once a month on a daily basis, and every two weeks on a weekly basis.

To evaluate monilia incidence, healthy pods, monilia and phytophthora infected ones, and those with any other injury were counted every two weeks. In addition, fresh weight per tree was evluated. Incidence was calculated as percentage of fruit in relation to the total.

No significant differences were found in temperature and relative humidity in each shade tree analyzed; however, singificant diferences were found under each shade.

Evidently, there is higher spore release from 29^{o}C on and at humidity levels between 71-74%.

Highly significant differences were found for spore counts in the air under the different shade tree species and also over time. Poró was the shade tree in which more spores were caught; guava and madero negro showed no difference between them.

No differences were found for monilia incidence betwwen shade species nor for interclonal crossbreeding.

There is no direct relationship between meteorological factors and spore counts in the different kinds of shades.

There is a relationship between number of spores under poró shade and monilia incidence after 15 days. For madero negro incidence was at 45 days. However, monilia incidence level is given by several factors as a whole, thus single effects rarely have a direct relationship, as shown by this study.

SOMATIC EMBRIOGENSIS AND PLANT REGENERATION FROM MALE FLOWERS OF BANANA AND PLANTAIN TRIPLOIDAL CULTIVARS

Jean Vincent Escalant
Juan Luis Ortiz
Luis Pérez

RESUMEN. La embriogenesis somática y la regeneración de plantas de cultivares de banano y plátano (Musa sp), se obtuvieron por medio del cultivo de flores masculinas jóvenes. La multiplicación y el mantenimiento de los cultivos obtenidos mediante la de embriogénesis, se lograron cultivando embriones somáticos en un sistema temporal de inmersión (SIT). Una tasa de reproducción de 40 permitió obtener más de 6000 embriones somáticos después de seis meses de subcultivo. Las frecuencias de recuperación de las plantas fueron de 60 a 70%. Este método fue expandido a diferentes grupos genómicos de banano y plátano.

Banana and plantain are part of the most important crops in the world, with a production of 70 million tons. Incidence of several diseases such as black Sigatoka, Fusarium, viruses and nematodes, which considerably affect production and its costs, makes development of new varieties and urgent priority. Since approximately sixty years ago, different programs of genetic improvement have been developed. However, due to sterility and polyploidy of triploidal cultivars, development of new varieties, through conventional methods, was very difficult. The new strategies include the use of biotechnology techniques in order to support conventional improvement programs. Among these techniques, genetic transformation allows the introduction of foreign genes for diseases resistance. The application of genetic transformation to cultured plants is increasing constantly. However, the main constraint to use this technique is that already exist very efficient methods for plant regeneration, utilizing tissue culture methods, such as somatic embriogenesis, cell and protoplastes suspension. This paper describes one of the most efficient methods developed for the Musa genus.

Embriogenic cultures are obtained from male flowers located at the top of the inflorescence. The selected flowers are within a range of 0 and 15 (0 corresponds to flower meristematic tissue). Studies were conducted on several group genotypes: Musa AAA cv, "Grande Naine", "Yangambi", Musa AAB cv. "Plátano Dominico", "Mysore" and Musa ABB cv. "Pelipita".

After two months of culture in an adequate culture medium, flowers responded by forming a yellow callus. After 3 to 5 months of culture, without any subculture being made, a translucent callus appeared on the yellow callus and a formation of several somatic embryos was observed on the surphase. These embryos look like flat small translucent structures and presented a cotyledonary silt.

Transfer of somatic embryos to the germination medium allowed to obtain 85% ofcomplete plants.

Somatic embryogenesis in temporary immersion.

The appraisal of somatic the embryogenesis method and its use for mass propagation or genetic transformation, requires the employment of a multiplication system in order to obtain continuous somatic embryo production. Different systems can be used for this purpose: subcultures in a solid

medium, cell suspension cultures, or an intermediate temporary immersion. The temporary immersion system was implemented because it represented a simple and very efficient method to be used in a genetic transformation program. The culture container consists of two parts linked by a filter system which allows the liquid medium to run between them, and not permitting the cultured embryos to pass through. Using a small pump, pressure is applied at the bottom, causing the liquid medium to go to the upper compartment, submerging somatic embryos for 1 minute every 12 hours. Once pressure is release, the liquid medium runs down to the lower part leaving embryos under saturated humidity conditions. Culturing is started with an embriogenic culture of 0.250g, approximately, carrying 150 embryos in a $2mg.l^{-1}$ enriched culture medium (Escalant y Teisson, 1989). After 6 months of subculture, multiplying rate reaches 40 plants, allowing to obtain an average of 6000 embryos. A slight change in the medium employed for the temporary immersion system, it was possible to obtain somatic embryos germination and their development into complete plants.

The method's originality is characterized by its application to several genotypes and by the introduction of the temporary immersion system as a very effective propagation technique. Although first results are not on in vitro regeneration of the Musa genus, this method is different and very original when compared to others (Dhed'a et al, 1991; Novak et al., 1989). Its efficiency allows its application for genetic transformation activities using particles gun. Besides, considering the very high multiplication rate obtained through the temporary immersion system, additional research to determine its possible applications for mass multiplication is recommended. It would be very intersting to include this method in a germplasm preservation program, developing studies on artificial seeds production.

In addition, a temporary immersion system could be applied to other species such as coffee, citrus, etc., allowing significant improvement of current propagation techniques.

However, all these applications require more information in terms of appearence of eventual mutant plants. Currently, 1500 plants are under the acclimatization process in order to be transferred to the field for prior evaluation.

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MICROBIAL CONTROL OF THREE ECONOMICALLY IMPORTANT PESTS USING THE ENTOMOPATHOGENIC FUNGUS Beauveria bassiana

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Geovani García, Saúl Brenes

RESUMEN. La patogenicidad y virosis de 13 aislamientos de B. bassiana fueron evaluados para el control biológico de tres plagas de importancia económica. Los mejores aislamientos fueron RL 9 y A4 para C. sordidus, 447 para P. xylostella y 447 y RL 9 para H. tarsatus. Se recomiendan estudios de campo para seleccionar las concentraciones y métodos de aplicación más adecuados.

Microbial pest control using entomopathogenic fungi offers several advantages over conventional chemical insecticides, such as decreased air pollution, non-toxic residues in the product, and few effects on beneficial insects and on human health (ALVES, 1986).

Efforts in this field have been addressed to the use of entomopathogenic fungi, especially Beauveria bassiana and Metarhizium anisopliae. The first task was to search for fungi in the field, in order to establish an initial reserve of isolates from different infected insects. This work was completed with the addition of some introduced isolates from other institutions.

Later, research was conducted with different pests which had shown potential for biological control with this type of fungi. The banana weevil (Cosmopolites sordidus) is one of the pests studied which has some history of control using B. bassiana; also the diamondback moth (Plutella xylostella) which is the most important pest in cruciferae and a hemiptera that attacks macadamia nuts (Hyalymenus tarsatus). The main purpose of this research was to select the most promising B. bassiana isolates against these pests based on pathogenicity and virulence.

In a first phase, pathogenicity and virulence of 13 B. bassiana isolates were evaluated in a dosage of 1×10^9 conidia per milliliter of fungus suspension. For C. sordidus, 10 adults were used per treatment (isolated) and per repetition. Application was made by immersing the insects into the fungus suspension. For P. xylostella, 15 larvae were used with topical fungus immersion, and for H. tarsatus, 10 nymphs were sprinkled with fungus.

In a second phase, lethal dosages (LD_{50} and 90) were evaluated for the different insects. An isolate showing the highest mortality percentage and lowest lethal time was used. The same methodology was applied but decreasing the dosage of the fungus from 1×10^9 to 1×10^5 conidia per milliliter, except for banana weevil for which 4×10^9 to 4×10^5 was used.

In a third phase, isolates were selected using a LD_{95} dosage of the most virulent isolates the same metohodologies of the previous phases were applied to the best isolates of the second phase. In the three phases, daily mortality, mean lethal time and mortality rate were evaluated. For lethal dosage calculation, "próbitos" methodology was used.

All thirteen isolates of B. bassiana were pathogenic against inoculated insects. However, mortality was higher than 90% in some isolates, namely, A4, Achi 2, RL9, Coyol 1 and 290 for C. sordidus of which, A4 stood out with 100% mortality. For P. xylostella 447, Achi 5, 167, A4, Achi 2 and Achi 1 isolates were the best, with isolate 447 standing out. For H. tarsatus, isolates 447 and RL9 were the best showing 100% mortality.

The mean lethal time which provides a general idea of isolates virulence was around 7.0 days for five of the isolates evaluated against C. sordidus; 0.2 days for eight isolates evaluated against P. xylostella, and 5.0 for isolates 447 and RL9 avaluated against H. tarsatus. Mortality percentage and lethal time allowed selection of highest virulent isolates which were later used for lethal dosage calculation.

Lethal dosage (CD_{50} and 95) was 8,7 x 10^7 and 2.7 x 10^9 conidia/milliliter for C. sordidus. It was 2.2 x 10^5 and 5.1 x $10.^7$ for P. xylostella and 1.18 x 10^6 and 2.7 x 10x 10^8 for H. tarsatus. The high figure shown for C. sordidus indicate that the fungus used in a solution is not adequate for field conditions; thus, its use as a powder or in addition to rice sustrate and trap applications is recommended (CARBALLO, ARIAS DE LOPEZ and BRENES, 1993). Solution can be applied for the other two pests.

A better selection of isolates was possible for P. xylostella when a LD_{95} solution was used, since only isolate 447 surpassed 90% mortality and LT_{50} of 3.32 days with a 5.1 x 10^7 dosage. For H. tarsatus, isolates 447 and RL9 caused 100% mortality and LT_{50} near 5.0 days, with a 2.69 x 10^8 dosage. Finally, isolates RL9 and A4 for C. sordidus surpassed 90% mortality and LT values of 6.35 and 8.92 days, respectively, with a 2.67 x 10^9 dosage.

Conclusions and recommendations. Highest B. bassiana pathogenic and virulent isolates were selected using mortality percentage, mean lethal time and lethal dosages (LD_{50} and LD_{95}) as parameters.

The best isolates for microbial control of the different pests were RL9 and A4 for C. sordidus, 447 for P. xylostella, and RL9 and 447 for H. tarsatus.

Isolates selected for each pest should be evaluated at the field level using different dosages and application methods. In additioin pathogenecity and virulence in most fungus isolates currently available, should be evaluated using similar tests at the laboratory level.

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WEED CONTROL AND SOIL PROTECTION IN COFFEE UNDER CONTROLLED SHADE: SELECTIVE WEED CONTROL, MULCH AND PERENNIAL LEGUME COVERS

Charles Staver

RESUMEN. Se estudiaron tres opciones de bajos insumos para promover una cobertura de protección del suelo y reducir la competencia de malezas: control selectivo de malezas como coberturas vivas, mulch de podas de árboles de sombra y coberturas perennes. La aplicación selectiva o por parchoneo de herbicidas redujo la población de malezas competitivas en un 50%, e incrementó la población de malezas para cobertura como Oplismenus burmanii en un 200% después de dos años. El mulch de Inga o Ficus redujo el número de malezas en un 80% después de dos meses, mientras que Gliricidia mostró poco control de malezas. Las coberturas perennes como Arachis pintoi redujeron el uso de malezas y herbicidas durante 3 años, protegiendo el suelo durante la época seca y la lluviosa, pero utilizaron más agua. Una plantación de café bajo sombra manejada es un mosaico de microambientes en el cual las tres opciones tienen lugar.

Updated technology for coffee production, characterized by a decrease or removal of shade trees, adoption of shrub- type varieties and increased use of agrichemicals have brought about negative environmental consequences. Current weed controls focus on total removal of existing vegetation over the ground, with yearly applications of up to three herbicides and of very persistent pre-emergent ones. Under these practices, soil is left unprotected for long periods of time resulting in higher erosion caused by rainfall and run-off, compaction and reduced filtering.

Integrated weed management in coffee should focus on decreasing weed and crop competition, and on soil protection. Three options for integrated management of soils in coffee plantations are being researched in Nicaragua: selective weed management to reduce competitive weeds and promote cover weeds which present creeper growth and superficial root systems (Staver et al., 1993); the use of small leaves and pruned small branches from different shade tree species (Rivas et al., 1993); and the establishment of perennial creeping legume as covers (Bradshaw et al., 1992).

Beginning in 1991, three experiments were set up, in Managua and Carazo, Nicaragua, a region where coffee has been grown traditionally, at 450-650 masl, an annual rainfall of 1200-1400mm, and a 5 month long dry season. In a trial from 1991 to 1993 on selective management in a recently planted coffee plantation, the effect of different herbicides applied 15-20 days after two prunings a year on the botanical composition of the weeds was evaluated: 1)pruning alone, 2)conventional (2.4-D + paraquat + simazine), 3)glyphosate, 4) 2.4-D and 5)flexible management using herbicides selectively according to occurring weeds. Fresh weed biomass was sampled twice a year in six $0.25m^2$ squares in each 1 x 10m plot between coffee trenches. In a trial on the effect of mulch for weed control, leaves and small pruned branches of Gliricidia sepium, Inga paterna, Simarouba glauca and Clusia rosea, species used as managed shade, were placed in 1.5 x 1.5 m plots in a productive coffee plantation in two thicknesses after a low pruning before the first rains began. Each of the four blocks had a control without leaf cover. Number of weeds (at 14, 28 and 63 days) and fresh biomass (at 33 days) were measured in four $0.0625m^2$ squares. Gramoxone was applied at 39 days. The trial on leguminous perennial covers compared Arachis pintoi and Desmodium ovalifolium growth in the alley with a weedy control and with the producer's weeds

management in 6 x 10m plots including a coffee row exposed to sun light. Weeds were measured three times a year in 8 0.25 m^2 squares. Total yield per plot was also measured. Soil humidity (2 depths, 10 holes) and hydrical stress (3 leaves in the pressure chamber) were measured monthly from November through May.

Feasibility of selective management focused on harmful weeds control and leaving only cover weeds was observed during the three years of the experiment. Table 1 shows the increase of weed covers when using 2.4-D alone and with flexible management consisting of broadcasted glyphosate for the first year, and spot application of 2.4-D and glyphosate for the last years. Use of clearings only provided good protection for the soil, but abundant weeds damaged the coffee crop. The conventional mixture and broadcasted glyphosate reduced harmful weeds, but leave the soil unprotected without cover weeds (See sampling 10/91). Each treatment showed different predominant weeds on 6/93; clearings-perennial broad leaf ($F=4.5^{*}$): conventional and glyphosate-annual broad leaf (tendency): 2.4-D grasses ($F=13.8^{**}$); flexible-cover weeds ($F=12.2^{**}$); showing that current weeds management leads to future weed problems. Herbicide use reached its minimum level under flexible management, at less than two liters for the last year. This type of management tends to be more conservation-oriented due to cover weeds predominance, more productive due to reduced competition between cover weeds and coffee, and more economical due to limited herbicide use.

Table 1. Selective management trial-fluctuations in fresh biomass of harmful and cover weeds and herbicide use.

	Fresh weeds biomass g/square						Herbicides lt/ha	
	6.91		10.91		6.93			
Treatments	wds1	cov1	wds	cov	wds	cov	91-93	93
Only clearing	217	2	230	150	362	36	-	-
Conventional	217	11	74	22	147	23	18	6
Glyphosate	269	3	168	32	263	9	12	4
2.4-D	249	2	118	190	397	63	9	3
Flexible	151	21	113	148	119	111	7	1.5

1 wds= harmful weeds cov= cover weeds

Mulch of leaves pruned from shade trees reduced weeds according to species and thickness during the two month trial. Mulch reduced number of weeds after 14 and 28 days compared with the control ($F=22^{**}$, 23^{**}). After 14 days 2067 seedlings/m^2 were determined for the control compared to 313 individuals for covers. Table 2 shows averages for the other dates. No significant differences in weed biomass were observed between the control and the covers, since each weed was likely to be larger in treatments with fewer weeds.

The rate of cover biomass loss was higher for Gliricidia than for other species ($F=73^{**}$), a factor possibly contributing to differences in number of weeds according to type of mulch. At 14, 28 and 63 days, number of slowly decomposing species was lower than quickly decomposing species of Gliricidia ($F=15^{**}$, 17^{**}, 67^{**}), resulting in no difference at all between Gliricidia and the control at 63 days.

No difference was found between thicknesses at 14 days, but at 28 and 33 days, when cover decomposition had just begun, double thickness showed fewer weeds than single thickness (F=3 (10%); 5.6*). In the final sampling, at 63 days after paraquat application at 39 days, no differences were found between thicknesses.

Table 2. Trial of shade tree mulch-weeds per square meter and percent age of mulch biomass by the end of the trial.

Treatment	Con1	Gs	Gd	Is	Id	As	Ad	Cs	Cd
Number of weeds 28 days	1641	1090	400	329	183	306	180	206	69
Weed biomass 33 days	381	551	239	350	141	316	213	249	88
Weight/weed 33 days	0.4	1.1	0.8	1.3	1.3	1.5	1.9	1.7	5.6
Number of weeds 63 days	655	581	382	74	71	74	82	57	118
% mulch 63 days	-	37	34	82	87	84	84	84	87

1 con= without mulch, G= Gliricidia, I= Inga, A= Simarouba, C= Clusia

Perennial legumes planted as covers proved to be an excellent weed control compared to the producer's management, before the first and after the last control during the rainy season (F= 10*; 22**), although in October there were few weeds in the producer's plot due to three herbicide applications. Arachis cover offered complete soil protection during the whole year, while Desmodium did not recover completely after the second dry season.

Regarding competition between coffee and covers, no differences were observed in terms of soil humidity or coffee hydric level between treatments during the first months of the dry season, although during the last month before the rainy season, in plots managed by the producer where weeds and legumes were non-existent, hydric stress was lower than for the other treatments. Density of coffee roots in the drip irrigation zone was higher in the producer's plot, indicating that treatments with legumes or dense weeds limited coffee root systems expansion.

No significant yield differences were observed between treatments, since data obtained was highly variable.

All three mechanisms studied allow soil management ground in coffee under managed shade, to reduce weed competition and protect the soil. Due to ground variability in regards to weeds, natural mulch from fallen leaves and shade degree, the use of mulch and legumes should complement selective management in plantations without natural cover weeds. This spot management is widely applicable to perennial crops in the tropics, and plays an important role within CATIE's programs emphasizing on sustainable management of natural resources.

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General pests of importance

EFFECT OF SEVERAL METHODS OF INTERFERENCE, DISTRACTION AND REPELLENCY FOR WHITEFLY, Bemisa tabaci, MANAGEMENT IN TOMATOES, IN COSTA RICA

Luko Hilje

RESUMEN: Las plántulas de bandejas protegidas con mallas durante sus primeros 30 días, crecieron bien y resistieron mejor el daño viral que aquellas sembradas sin mallas. Además, la reducción de contraste entre suelo desnudo y el cultivo, por medio de malezas que crecieron espontáneamente, y la posible repelencia de bifentrina (Talstar) e imidacloprid (Condfidor), disminuyeron significativamente la abundancia de B. tabaci adultos y retrazaron la diseminación viral. La integración de esos tres enfoques procederá en la futura validación en-finca para el manejo de la mosca blanca en Costa Rica.

Agriculture in Central America and the Caribbean is presently facing a severe crisis, caused by whiteflies, Bemisa tabaci (Gennadius) (Homoptera: Aleyrodidae). Although in some countries it causes direct injury, the main damage is due to geminivirus dissemination. Its control using conventional and biological insecticides has not given the expected results, due mainly to the fact that a very small amount of adults can rapidly disseminate virulence in an entire plot.

This paper summarizes the information generated recently for table tomatoes, with the scope of Integrated Pest Management (MIP) which, based on the crop's crucial period, emphasizes interference, distraction and repellency approaches (Hilje, 1993). This information was obtained from four experiments for graduate theses research, supervised by the author, on the following subjects: seedling orchard management (MASEM), by Galileo Rivas; soil covers (COBSU), by Ricardo Amador; crop traps associated with insecticides (TRAIN), by Leslie Peralta, and repellent substances (SUREP), by Lorena Soto.

Experiments were conducted at the Fabio Baudrit Experimental Station (UCR), Costa Rica, during the dry season of 1993. It is located in the Premountain Humid Forest life zone, in San José and Alajuela, at 840 masl. Its annual mean temperature is 22,4°C and the annual rainfall is 1930 mm. For all experiments, the variety used was Hayslip, which was grown and then transplanted into No.98 Tray Masters (V-J Growers, Florida) plastic trays, covered with Agronet-S (Kayserberg, Germany) Net; in MASEM, an additional tray and net were included. The media employed was a mixture of soil, grain residues, chicken manure and 10-30-10 formula (N-P-K) at 10:2:1:0,1 proportion. In the field, planting spacings were 1,2 m between trenches and 0,4 between plants.

For MASEM, study factors were the nets and the trays. Treatments were six combinations of nets and two of trays. The nets were Agronet-S and a non-agricultural nylon one, and trays were Tray Masters # 72 and 98. These were placed into 0.8 X 0.7 X 3m tunnels, where seedlings grew for their first 30 days. After transplanting, a completely random block design with four blocks and a 3X2 factorial arrangement was used. The field experimental plot was 5 X 6m. Insecticides were not applied at the seedling orchard or at the field level.

For COBSU, transplanting was conducted after 37 days. A completely random block design with four repetitions was used. The experimental plot was 6m long with a width of 6 trenches at 1.2m spacings; blocks were separated by 5m interplots. Treatments were yellow plastic, green plastic, rice residues, peanut fodder, Arachis pintoi, weeds grown spontaneously and the control without covers. For transplanting, 10 cm diameter holes were made to the plastics at planting site. Peanut fodder was vegetatively planted 40 days before transplanting. Weeds grown spontaneously were left for free growth with weekly watering.

For TRAIN, transplanting was done after 42 days. The trap crop was beans (Phaseolus vulgaris), Dorado 364 variety, planted 15 days before tomato transplanting. A completely random block design with four repetitions was used. The experimental plot was 5m long and 7.2 m width, including double bean trenches in both sides, planted at 0.6m from tomatoes. Treatments were: tomatoes + beans + imidacloprid in beans; tomatoes + beans + carbofuran in beans; tomatoes + beans + imidacloprid in beans + oil in tomatoes; tomatoes + beans + carbofuran in beans + oil in tomatoes; tomatoes + beans + oil in tomatoes; tomatoes + oil in tomatoes + tomatoes without application. Granular insecticides, imidacloprid (Gaucho 70WS) or carbofuran (Furadan), were applied at planting, at the recommended dosage. Agricultural oil Volck 100 Neutral was applied to tomatoes every 3-4 days, up to 68 days after planting (dap), at 5cc/l of water plus 0,25 cc of emulsifier.

For SUREP, transplanting was carried out after 26 days. A completely random block design with four repetitions was used. The experimental plot was 6m long, with a 6 trench width, at 1.2 m spacing. Evaluated substances had proven repellent action (Endosulfan) and others were presumably repellent. Treatments were: endosulfan (Thiodan), imidacloprid (Gaucho), bifenthrin (Talstar), Volck 100 Neutral agricultural oil, neem extract (Copinim, Nicaragua), hot pepper extract and a control, without applications. All were applied twice a week during 30 days after transplanting. Dosages used were those indicated on the label; a 0.08% concentration was used for hot pepper, and as previously indicated for Volck 100 Neutral.

In the four experiments, number of adult whiteflies, virus incidence and yields were evaluated. The first two were weekly evaluated or every 3-4 days, depending on the experiment. The number of adults was evaluated in the third opened leaf after outbreak, before flowering; then it was evaluated in the leaf immediately below the highest inflorescence with at least one open flower ("key" leaf). Virus incidence was determined for all plants in the plot. For yields, three conventional fruit categories were used according to weight and diameter: I (>160g, >7cm), II (120-160 g, 5.5-7cm) and III (<120g, <5.5 cm).

Relevant results from each experiment are as follows:

In MASEM, seedlings grew well in both types of trays. At transplanting, they looked good, had hairy stems and abundant root systems, but those from seedling orchard seeds protected with a net surpassed the rest in height and weight. Establishment costs were higher for protected treatments, especially in the one with nylon, but lower than direct planting costs during the first month. Vector abundance did not show statistical differences between treatments. In the field, 50% of virus incidence was delayed 45 days in the treatments from protected seedling orchard seeds, in comparison with the unprotected ones.

In COBSU, decreased contrast between soil color and the crop diminished adult attraction and delayed virus dissemination. Living cover (peanut fodder and weeds grown spontaneously), were statistically superior to other treatments, especially weeds. In these these experiments assays, 50% of viral incidence was delayed 12.3 days compared to the control.

In TRAIN, no significant differences were found between treatments. However, the number of adults up to 70 dap was low for all treatments, no more than 10 adults/plant, while in the adjacent experiments (MASEN and SUREP) 40-60 adults/plant were found. This suggests that beans (which, due to the experimental design characteristics were around all tomato plots), acted as trap crop or "drain" where adults went and became intoxicated; low numbers in the trap crop, rarely more than 3 adults/plant, reinforce this idea.

In SUREP, Talstar and Condifor stood out. For the former, the number of adults never surpassed 10 adults/plant, while for the latter it reached 25 adults/plant and up to 129 for the control. 50% of virulence appeared at 55 dap in the control, 57 dap in the treatments with neem, oil and hot pepper, and 59 dap in the Thiodan and Confidor treatments; for Talstar 43% virulence had not been reached yet by 62 dap, when data collection was completed.

In summary, several results, although preliminary, are promising to be implemented in the IMP framework (Hilje 1993). Although the best measure for virus impact is yield, a severe attack of Pseudomonas solanacearum bacteria prevented obtaining representative yields in the four experiments. However, if 50% of infected plants are used as a comparative criterion, in relation to direct planting, the use of trays and nets delayed infection in about 5 days, to which at least 10 days can be added with the use of Talstar and 12 weed cover. Theoretically, integration of all these approaches would delay virulence at least 22 days, but this should be experimentally evaluated or validated on farmers plots. Simultaneously, it is necessary to optimize seedling management at the seedling orchard, as well as to explore other alternatives suggested during the development of the four experiments.

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Non-traditional export crops

FUNGI OR THRIPS, CAUSAL AGENT OF POD SPOTS IN SNOW PEAS, ALTERNATIVES FOR CONTROL

Víctor E. Salguero

RESUMEN. Se realizaron siete experimentos para determinar el agente causal del manchado de la vaina de la arveja china y desarrollar alternativas para controlarlo. Este trabajo fue realizado en el altiplano guatemalteco de 1991 a 1993. Los agentes responsables del manchado de la vaina son trips cuando éstos se alimentan u ovipositan. El uso de trampas pegajosas amarillas combinadas con insecticidas proporcionaron el mejor control.

Growing snow peas crop, Pisum sativum, began more than 15 years ago in Guatemala. Presently, it has become an important export crop grown on about 10.000 ha of the central highlands, and benefitting many small and medium producers.

The main pest problem for the crop are fungal diseases which are thought to cause pod spots. Lambe et al. (1990) found Ascochyta sp. to be the fungus causing foliage and pod spots. Pod spots causes this product to be rejected by processing plants. Thus, sanitary programs for snow peas are based on fungicide use.

This paper summarizes the results of several experiments aimed to:

1. Determine the causal agent of pod spots in snow peas.

2. Develop alternatives to control the causal agent of pod spots in snow peas.

Two experiments were conducted to determine pod spot's causal agent:

1. Evaluation of fungicides and planting spacing in snow peas, March through May, 1991.

2. Damage characterization and identification of thrips species affecting snow peas, February through November, 1992.

Once thrips were determine to be the main causal agent of pod spots, 5 experiments were conducted to develop control alternatives:

1. "Thrips and leafminer control to diminish pod spot incidence in snow peas," May through July, 1991.

2. "Evaluation of 4 trap colors to catch thrips in snow peas," May through August, 1992.

3. "Evaluation of 2 types of traps for thrip control in snow peas," April through July, 1992.

4. "Traps, insecticides and combination of these for thrip control in pod spots," August through December, 1992.

5. "Evaluation of chemical insecticides for thrip control in snow peas," January through August, 1992.

All experiments were conducted in the Guatemalan highlands, in Sacatepequez and Chimaltenango Departments, and are reported by García et al (1993) and García Turnil et al. (pp).

What is the causal agent of pod spots?

To determine the causal agent of pod spots in an experiment to evaluate fungicides against Ascochyta, spot samples were taken from the pods in order to isolate and identify occurring fungi. Spots were of 2 types: black spots, or others in the shape of sandpaper or small welts, the latter being more frequent. Ascochyta fungus was isolated from the black spots. However, no other fungus was isolated from the most frequent spot.

Later, pods showing welt or sandpaper damages were incubated in order to determine insect emergence. Thrips were found to be responsible for this damage as they feed or oviposit. Damage by oviposition causes small green and white spots. Damage caused by feeding shows up as small black dots. Thrips species associated with this damage are: Frankliniella occidentalis, F. insularis and Thrips tabaci.

The feasibility of using sticky traps was evaluated taking advantage of thrips preference for some colors. The first study showed that yellow and white colors were more attractive to thrips. However, as white traps catch many beneficial insects, yellow is recommended. Then, 2 types of traps, strip and bag, were evaluated. Although strip-type traps catch more thrips, bag-type traps are more practical.

Six insecticides with EPA registration for broccoli were evaluated. Malathion, carbaryl and endosulfan proved to be most effective for thrip control.

In a final experiment, individual and combined effects of using traps and insecticides were evaluated. The use of traps and insecticides together provided the best thrip control, presenting only 20% rejection against the product, while insecticides, traps and absolute control showed 30, 40 and 60% rejection, respectively.

1. It was determine that thrips are the main causal agent of pod spots in snow peas.

2. The use of traps and insecticides combined effectively controls thrips.

3. To develop alternatives for more effective thrip control, preferably with non-chemical alternatives, is suggested.

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STUDY AND MANAGEMENT OF ITCHGRASS (Rottboellia cochinchinensis) Lour W.D. Clayton) in the DRY PACIFIC AREA OF COSTA RICA

Carlos E. Rojas, Ramiro de la Cruz,
Philip J. Shannon, Arnoldo Merayo

RESUMEN. Estudios de sistemas de manejo integrado para Rottboellia cochinchinensis en una rotación maíz-frijol y el comportamiento de la semilla en el perfil del suelo se llevaron a cabo en el Pacífico seco de Costa Rica. Para el tercer ciclo del maíz, los programas de control integrado seleccionados redujeron marcadamente las poblaciones de caminadora; la menor población de caminadora fue observada para el barbecho manejado sin labranza y control en cultivo con herbicidas. La viabilidad de pérdida de semillas sobre la superficie del suelo fue de 48% después de 12 meses. La mayor dormancia se encontró a los 20 cm de profundidad (24%).

Rottboelia cochinchinensis is a very aggressive and competitive annual weed found in tropical and subtropical regions. Itchgrass is considered one of the most important weeds limiting basic grain production in the dry Pacific and Atlantic areas of Costa Rica (HERRERA, 1989). A marked reduction in crop yields due to itchgrass competition and its control costs limit planting areas for medium and small farmers. This research was conducted to determine the effects of integrated management practices which consisted of combinations of tillage practice, chemical control during the crop cycle and fallow management on subsequent itchgrass populations, and estimate longevity of itchgrass seeds at different depths in the soil profile.

Both experiments were conducted at the University of Costa Rica Experimental Station in Santa Cruz, Guanacaste, at 54 masl and an average annual rainfall of 1800mm. An itchgrass management study began in September, 1991 under the maize-bean rotation system. Management practices evaluated are: fallow management (December-May); clearing, paraquat application (0.5 kg i.a/ha) and without fallow management; tillage practices: zero tillage and mechanized tillage (one plowing and two harrowing ones at 20 cm depth); in-crop chemical control: pendimethalin + alachlor (1.0 + 2.4 kg i.a/ha) (H1), pendimethalin at 1.25 (H2) and 1.5 Kg i.a/ha (H3) and without control (h4). Fallow management was carried out to prevent itchgrass seed production from December through May, tillage was done before planting maize in May and before beans by the end of August or beginning of September. Chemical control treatments were applied in both crops using equipment pressurized with CO_2, with an application volume of 285 litters/ha at 30 psi pressure with stainless steel nozzles 8002.

To determine itchgrass seed longevity in the soil profile, four 100 seed groups were buried in water-permeable polypropylene envelopes at 0.5, 10 and 20 cm depths in a clay soil in February, 1992. Envelopes containing itchgrass seeds were collected at 1, 2, 4, 6, 8, 10 an 12 months after buried. Seed collected was separated according to the Schafer and Chiclote (1969) model in the following components: $S = P_{ex} + P_{end} + D_g + D_n$, where S is total number of itchgrass seeds initially buried, P is the persistent part of the seed and D represents non-persistent seed part. The non-persistent part (D) was separated into two groups, in situ germinated seed (D_g) and seeds having lost their viability (D_n); ungerminated seeds were placed under greenhouse conditions and a germination counting was conducted after 15 days, those seeds that germinated were considered under forced latency (P_{ex}) and a tretazolium test was carried out for the ungerminated seeds to differentiate non viable (D_n) seeds from seeds under innate latency (P_{end}).

Significant effects were observed due to fallow management practices (P 0.05) in the May 1993 maize crop, the third cropping cycle after the itchgrass experiment was set up. High itchgrass population density was observed for the treatment without managed fallow, compared to managed fallow treatments; a lower population density was also observed in zero tillage plots than in plots under mechanized tillage ($P<0.05$). Finally, the use of any in-crop chemical control showed a highly significant effect on itchagrass populations ($P\leq0.0001$). No significant interactions between treatments were observed. Thus, combination of zero tillage with the best fallow management treatment and in-crop chemical control for itchgrass is likely to be the best integrated program for itchgrass management (Table 1). For 1992 and 1993 maize cropping cycles, only herbicides application showed a significant effect on yield ($P\leq0.0001$). Maize yield in 1992 was higher, probably due to low rainfall in July, 1993 (124mm) after flowering. This may also be the reason for great differences observed between treatments with and without in-crop chemical control, for the 1993 cycle (Table 1).

Table 1. Effect of selected control programs on R. cochinchinensis population density (means of non-transformed plants/0.25m2) and crop yield (Kg/ha) at 12% humidity during three cropping cycles in Costa Rica.

	Itchgrass population				
Yield	5-92	9-92	5-93	5-92	5-93
Practice	45[1]	45	45	Maize	Maize
WITH IN-CROP HERBICIDE[2]					
With Fallow Management					
Zero tillage	3.5	1.2	1.0	3525	2908
Mechanized tillage	4.1	2.5	1.5	3688	2917
Without Fallow Management					
Zero tillage	3.2	1.3	2.0	3708	2617
Mechanized tillage	4.5	2.9	2.1	3618	2158
WITHOUT IN-CROP HERBICIDE					
Without fallow management					
Zero tillage	18.9	6.5	10.4	2396	650
Mechanized tillage	18.5	11.1	13.5	2146	700

1 days after planting
2 data are means for three treatments with H1-H3 herbicides

Long-term effects of selected control programs are reflected in their ability of greatly reducing itchgrass populations, contributing to an important decrease in control costs and a possible increase in basic grains planting area.

The most relevant results of the study on itchgrass seed longevity in the soil profile are: 48% of seeds under the ground rotted after 12 months after being buried, 53% of seeds at a depth of 5cm germinated in situ, and the highest percentage of seed latency (24%) was observed at 20 cm after 12 months.

If itchgrass seed production is prevented, population densities of this weed, in cultivated soil, will be likely to decrease for the period of one year, especially if zero tillage is used. These results are similar to those reported by Bridgemohan et al. (1991).

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FODDER POTENTIAL OF WHITE MULBERRY TREE (Morus sp.) UNDER HUMID TROPICAL CONDITIONS

Jorge Benavides

RESUMEN. Este documento resume la investigación sobre el potencial de la Morera (Morus sp.) como especie forraje para cabras. Los resultados mostraron que la especie tiene buena capacidad para mejorar la producción de leche. La producción de biomasa se reduce con la cosecha frecuente, pero podría ser mejorada con los cationes aphh del estiércol de cabras. Es importante estudiar la especie en áreas de ladera y producir forraje para cabras.

White Mulberry is a tree or bush traditionally used for silk worm feeding. It belongs to the Urticales order, Moraceae family, Morus genus. This paper summarizes the research conducted at the Fodder Trees and Small Ruminants Unit, located at CATIE, Turrialba, Costa Rica, 650 masl in a Premountain Humid Rainforest life zone (Holdridge, 1978). The average annual temperature is 21,4 ^{o}C; the average rainfall during the last 41 years was 2630mm and relative humidity 87.9%.

The work with goats, in vivo dry matter digestibility (IVDMD) and crude protein (CP) of White Mulberry foliage was studied using metabolic cages especially designed to work with nursing animals (Jegou, et al, 1991). In the second experiment, the effect of Morera as supplement of milk production on goats fed with a basal diet of King-grass (Pennisetum purpureum x P. typhoides) was evaluated (Rojas y Benavides, 1993). A simple Latin Square Design was used, with two 4x4 square (early and late nursery animals), and four treatments (1,0; 2,0; 3,0 and 4,0%) of DM in relation to live weight.

Regarding agronomic aspects, the effect of goat manure application on White Mulberry biomass production was evaluated (Benavides et al., 1993). A split plot design with four repetitions was used. Large plots corresponding to fertilization (Jegou et al., 1991) and subplots to cutting intervals of 90 and 120 days (Benavides et al., 1993). Fertilization consisted of three manure levels (240, 360 and 480 kg/N/ha/year) and two controls: one of them without fertilizer and the other with ammonium nitrate (480 kg/N-/ha/year). The material was established by stalks at a density of 22 727 plants/ha.

According to laboratory data, White Mulberry foliage is one of the best known forages. CP concentration ranges between 20 and 25% and IVDMD varies between 75 and 85%. These results are assessed by the IVDMD (79,3%) and CP (89,6%) found in the metabolic cages (Jegou et al., 1991).

When White Mulberry foliage was used as a supplement for goats under a King-grass pasture basal diet, a strong positive effect on milk production was found (Rojas y Benavides, 1993) (Table 1). Production obtained using increasing foliage levels was higher than that obtained by Costarrican commercial enterprises using feed concentrates (Navarro, 1983), and even higher to that observed for milking goats fed with King-grass but also with Poró (E. poeppigiana) and banana fruit (Samur 1984; Esnaola y Ríos, 1986) as feeding supplements. No similar milk production levels have been found in literature using only fodders. In a three year research work, 854kg milk/lactation (2,8 kg/an/day) was obtained with goats fed exclusively with King-grass pasture and White Mulberry as supplement (Oviedo, Vallejo y Benavides, 1993). This production would be equivalent, in terms of metabolic weight, to 4800 kg/lactation (15,7 kg/an/day) in a 400kg weight cow.

Cutting intervals had no effect on leaves and edible material, although they affected total DM yield, produced by an important increase of woody material as intervals were increased. Biomass production increased significantly among years and application of increased amounts of manure to the soil (Table 1). Besides, production obtained by using manure was higher (22,9%) than that attained with NH4-NO3, in nitrogen-equivalent terms. This could be explained by the presence of other manure nutrients in the soil. For the first two years, a linear effect was observed between N application from manure (x) and N amount fixed in biomass (Y). ($Y=399,1 + 0,36X$; $r^2=0,93$; $p<0,05$). Regression coefficient was 0,26 for the first year and 0,45 for the second year, which means plant efficiency in nitrogen use.

Table 1. Effects of White Mulberry (Morera spp) foliage as supplement on milk production, and of manure applications in the soil on biomass production in Turrialba, Costa Rica.

Milk Production kg/goat/day	Supplementary level 1,0	1.8	3,8	%PV[1] 3,4	X
Late lactation[2]	2.04	2.38	2.51	2.47	2.35
early lactation[2]	1.64	1.82	1.91	2.12	1.87
Average[2]	1.84	2.10	2.21	2.29	

Biomass Production	Manure level in the soil				NH4-NO3
mt/DM/ha/year	0	240	3604	480	480
Total[2]	19.93	24.15	26.08	30.065	24.48
Leaf and young stem[2]	9.64	11.59	12.34	14.105	11.35

Adapted from Rojas and Benavides, 1993 and Benavides et al., 1993. 1/Live weight percentage in terms of DM, 2/Significant linear effect ($p<0.01$). 3/Data from three years, 4/Equivalent to Kg N/ha/year, 5/Statistical differences between higher manure level and N4-NO3 ($p< 0.01$).

The economical analysis carried out showed that 1 kg of White Mulberry DM of fodder equals US$0,056; while 1 kg of feed concentrate is US$0,148, that is, almost three times the former (Rojas, 1992). Another bioeconomic evaluation (3 years) conducted in an agroforestry module for small farms, where feeding is based on White Mulberry King-grass exclusively, showed a cost/benefit ratio of 1.36 including labor and 6,78 if it is not included (Oviedo et al., 1993).

In the future, several agronomical management factors should be studied, according to the different production systems and to the vaired ecological and topographical conditions existing in Central America. Above all, it is very important to evaluate the effect of those factors in sustainable production and on soil conservation. Aspects related to planting time are more relevant under

dry tropical conditions than under adequate rainfall climatic conditions. This effect has not been studied enough, and it may probably have an important effect to establish vigor (rooting) and survival of the seeds. Development of planting methods on slope is very important for the development of alternatives in order to prevent or diminish erosion problems.

Undoubtedly, the main constraint for White Mulberry production is its dependency on soil nutrients. Thus, this paper was focussed on fertilization-related aspects. However, several alternatives still require evaluation, such as the use of other kind of organic manure and its association to nitrogen fixing plants in order to use foliage as green manure.

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INTEGRATED MANAGEMENT OF NATURAL RESOURCES PROGRAM

INTEGRATED MANAGEMENT OF NATURAL RESOURCES PROGRAM (MIREN)

Dr. Carlos Rivas Pagoaga

The work presented during this scientific week at CATIE reflects the concerns and commitments of the Center with regards to present and future uses of tropical natural resources.

The MIREN program has made an effort to efficiently develop and transfer conservation practices throughout the region by providing appropriate technologies tailored to the special needs of the member countries so that they may manage and wisely use their natural resources (including water, soils, forests and biodiversity) which in most cases are the base of economic development in the region.

The focus of the program is the modified anthropocentric view of the use of natural resources that allows the sustainable and wise use of natural resources while at the same time permitting production activities and economic growth in tropical countries.

In the decade of Agenda 21, a global responsibility has emerged to fight against poverty and to protect the environment by increasing the productivity of the resources, and hence improving income levels; incorporating individual communities in the decision making process related to population growth and the use of natural resources, improving health and education; and ensuring that individual communities have the ability to help themselves.

The commitment of CATIE, working through the Integrated Management of Natural Resources Program, is to bridge the gap between the researchers and user of new technologies. We must continue to use and refine the participatory research process so that the useful results can be easily adopted and utilized by the actual resource users.

STUDIES OF THE GROWTH AND YIELD OF TIMBER TREE SPECIES IN PRIMARY AND SECONDARY NATURAL FORESTS IN SARAPIQUI, COSTA RICA

Bryan Finnegan

RESUMEN: Estudio sobre el incremento de diámetro en especies comerciales de árboles llevado a cabo en parcelas de experimentación permanente en bosques húmedos tropicales primarios y secundarios bajo manejo sostenible. Los incrementos diamétricos medianos de los árboles potencialmente productivos son de 0,5 cm/año en los bosques primarios y con frecuencia >1,0 cm/año en los bosques secundarios. Las intervenciones silviculturales demuestran un aumento en los incrementos en los dos tipos de bosque.

The sustainable management of natural resources in general, and natural forest in particular, is a goal not a reality. There is enough general information to implement the management of the natural tropical forests of Central America. The necessary specific information to assure an optimum sustainable use of this resource should be obtained through research programs and monitoring of forests under management.

Since 1987, research has been undertaken in Costa Rica to obtain specific information on aspects of sustainable production and conservation of natural tropical lowland forests. Two types of forests are studied, representing the natural forest resource subject to a multiple use management in the North Zone of the country. The exploited primary rain forest, defined as the natural original forest, altered by past and uncontrolled wood exploitation, and secondary rain forest, defined as the woody vegetation developed in sites that are abandoned after its original natural vegetation is destroyed by man.

This article reports on the research on aspects of sustainable timber production. The research carried out on a farm of the canton of Sarapiquí (200 m. above sea level) focuses on growth, yield and natural regeneration, and seeks to answer the following specific questions: 1. What is the magnitude, variation and distribution of the diameter increments of the trees of the future crop and what is the effect of silvicultural treatment on these factors? 2. What are the intrinsic factors (initial diameter, condition of the tree, etc.) that determine the magnitude, variation and distribution of the diameter increments and how can this factors be manipulated by the silviculturist? 3. How can we predict: the future growth of a stand or an individual tree based on its actual state; the periods of rotation or the duration of the felling cycle and the production of the future yield?

Growth and yield monitoring is carried out within permanent sample plots. In the exploited primary rain forest were established in 1988 nine plots of 1,0 Ha with buffer zones of 40 m wide, for a total extension per plot of 3,24 Ha and the whole study of 29,16 Ha^{-1}. In the secondary rain forest were established in 1986 plots of 1,16 - 1,6 Ha^{-1} in five forests of different ages (3 years, two plots of 15 years and two of 25 years at the beginning of the study). Due to the great variability demonstrated by the secondary forests, these plots cannot be considered formal replicates.

In all these permanent sample plots, it is annually measured the growth of all the trees and palms >= 10 cm DBH (diameter at breast-height - 1,3 m), and are determined the mortality and recruitment rates. Besides DBH, other variables are observed, that could be affecting in one way or

the other, the growth of the trees like the shape and exposure to solar light of the crowns (evaluated in a subjective scale of 1 to 5). Coordinates within the plot are measured for each individual, to make possible the calculation of competition indexes. All the species present in the plots are identified to facilitate the analysis of the effect of the management on the composition and floristic richness of the vegetation. There are also made detailed studies of the natural regeneration (trees <10 cm DBH). The results of these last studies are not presented in this article.

All the plots of the exploited forest were subject to a controlled harvest in 1989 and 1990. Silvicultural treatments post-exploitation were applied to the plots in a complete randomized block design (three replicates), with control (exploitation without subsequent treatment), silvicultural liberation of trees of future crop (applied in 1991) and protecting canopy (applied in 1992-1993). Here, the control plots and the liberation plots (six plots) are analyzed and compared.

Within the 6 Ha considered, and during the 5 years of measuring it was measured a total of 3191 trees (> = 10 cm DBH) resulting in an average of 532 trees per Ha. The initial basal area (G) of the forest was 23 m^2/Ha^{-1} and it did not differ too much among the plots, even though the number of trees was always greater in plots that did not receive the liberation treatment. The liberation plots demonstrated a reduction of G of 25% while in the control plots the reduction was only 7% due, mainly, to the exploitation. Up to this moment, 218 species have been identified in the 6,0 Ha^{-1}, from which 54 are classified as commercial and 7 are palms.

In the secondary rain forests of 15 and 25 years of age, the intermediate canopy was thinned in the sub-plots in 1989, leaving as control (without treatment) approximately half of the area of the plots. The products of this thinning were used as firewood in the black pepper processing of the farm and the costs and benefits from the operation were evaluated in a preliminary financial analysis of secondary rain forest management.

Up to this moment, the most important results from the exploited primary rain forest study are the following. For the diameter increment analysis, the commercial species were classified in two ecological groups, long-lived intolerants and tolerants. From a total of 777 commercial trees (24% of the total) measured during all the five years, the 65% were tolerants frequency. Trying to obtain more homogeneous subpopulations, the trees of each ecological group were grouped in five diameter classes (DBH at the beginning of the study), 10-19,9 cm., 20-29,9 cm., 30-39,9 cm., 40-49,9 cm. and >50 cm.

No matter how the grouping trees was made for analysis, the distributions of increments showed a positive skew (with median and moda smaller than the mean) and a high variance (variance coefficients >60%). Until 1992, the median increment oscillated around 0,5 cm/year, with a range between 0 and 1,5-2 cm/year for the two ecologic groups and in all diameter classes. Thus, a tree of future crop of 10 cm. DBH and median increment would take 80 years to reach a minimum felling diameter of 50 cm. and a tree of maximum increment, only 25 years. The times corresponding to a 40 cm. tree are 20 and 5 years respectively.

No liberation treatment effects were detected on the diameter increments for the period 1991-1992. However, for the commercial trees with an initial diameter of 10-40 cm., the median increments in the treated plots were substantially greater than the ones of the control plots in the period 1992-1993. This result indicates that competition for light and soil resources affects the growth of the trees for future crop and that competition can be manipulated by the silviculturist to increase the production of the system. More specifically, the light factor seems to play a key roll. In this complex natural vegetation, the percentage of the variance of the increments explained by a given intrinsic or environmental individual factor was always < 50%. However, it should be noticed that

the correlation analysis of the increment with intrinsic factors of the tree demonstrated a significative relation between diameter increments and both, the form of the crown and the exposure of the crown to sun light (Table 1). Preliminary models of multiple logarithmic regression including as independent variables the already mentioned factors, plus the initial diameter and the degree of infestation of the crown by lianas, explain higher percentages of the increment variance.

Table 1. Primary rain forest: median annual increments of timber trees of two ecological groups in five categories of crown form

Shape of Crown	Median Increment Intolerants (cm/year)	Median Increment Tolerants (cm/yr)
1 Perfect	1,10	0,75
2 Good	0,65	0,60
3 Tolerable	0,40	0,50
4 Poor	0,12	0,20
5 Very poor	0,10	0,20

The conclusions from the analysis made up to this moment, indicate the following: 1. The increments demonstrated by the trees of future crop > = 10 cm DBH indicate there will be no major problems to assure a profitable crop of this kind of forest, approximately every 20 years; 2. The trees in micro sites, better illuminated, form strong crowns and grow rapidly; silvicultural liberation assures that a greater proportion of the trees of future crop is in those micro sites and, therefore, increases the increments.

The study of secondary rain forests shows marked differences in patterns of diameter increments with respect to the primary forests. The following differences are probably due to the fact that the secondary rain forests do not show canopy gaps, characteristic of the primary rain forests and because they are dominated by a tree even-aged population. The latter factors contribute to reduce the complexity of the study of diameter increments in secondary rain forests. This research reports the growth of the main commercial species in forests of 15 and 25 years old at the beginning of the study, as well as the factors that affected them during the period 1987-1992. These plots are denominated in accordance with their age 15a, 15b, 25a and 25b. The following results include first, a brief basic characterization of the structure and composition of the four forests and second, the growth analysis that answers the above mentioned questions.

At the beginning of the study, the range of basal area in the four forests was of 16 to 25 m^2/Ha^{-1}, nearly the level of the primary rain forests of the zone, and the range of number of trees was of 510 to $760/Ha^{-1}$, superior to that obtained in primary rain forests (all data for trees > = 10 cm. DBH). As it is typical, there was dominance by one or two long-lived intolerant timber species in each forest> Goethalsia meiantha (15a; $n=293/Ha^{-1}$), Simarouba amara and Laetia procera (15b, $n=141/Ha^{-1}$ and $183/Ha^{-1}$, respectively), Vochysia ferruginea (25a,$n=133/Ha^{-1}$) and Laetia procera (25b, $n=90/Ha^{-1}$). Three dominant species —Simarouba amara, Laetia procera and Vochysia ferruginea— were selected for the following growth analysis. At the beginning of the study, dominant trees reached 30-50 cm. DBH in Vochysia, 20-30 cm. DBH in Simarouba and only 15-25 cm. DBH in Laetia. For this analysis, it is assumed that the population of each species is approximately even-aged.

In general, the increment distributions were positively skewed and the C.V. high (sometimes > 100%), only in the smaller diameter classes (compare this situation with that of the exploited primary rain forest). Among dominant trees and co-dominant, the C.V. were very reduced (only 20% in Simarouba) and distributions were symmetrical or negatively skewed. In the independent variables measured, initial diameter was the one that showed the greatest correlation with increments. The best fit was obtained with linear models, because in these immature secondary rain forests the big trees grow faster. In practical terms this means that, as in a forest plantation, the majority of the dominant and co-dominant trees grow fast, while the sub-dominant and suppressed trees have a very low productive potential.

At a more specific level, important differences were presented among the species with respect to the magnitude, the variation and the distribution of increments. Dominant and co-dominant trees of Simarouba (15b) and Vochysia (25a) showed median annual increments greater than 1,5 cm. and 1,0 cm. respectively, during the study. Simple linear regression models with the initial basal area per tree as an independent variable, and the increment of basal area per tree as response variable, generated a R^2 of 83% for Simarouba (15b; n=210) and of 66% for Vochysia (25a.; n=165). In these two cases it can be concluded with some confidence that, on one hand, the dominant and co-dominant trees are and will continue to be the most productive of the stand (offering crops of $150m^3/Ha^{-1}$ or more in 30 years or least), and on the other hand, the trees with smaller diameters grow slowly.

Laetia presented a different behavior in comparison to the two other species. From the analyzed species, Laetia is the one with a slower growth and is always in the intermediate canopy in secondary rain forests, dominated by species like Vochysia ferruginea and Simarouba amara. However, it is of great interest for its abundance and for the possibility it offers to diversify secondary rain forest production, because its wood is used for parquet floors. In the case of Laetia, the fit to the linear model of increment of the basal area was only regular, with values of R^2 around 30%. In this species, factors additional to the initial size of the tree are important in determining increments. Among these factors clearly figures the competition. In plot 15a for Laetia trees of 10,0-14,9 cm. initial DBH, increments of trees with adequate crown illumination were significantly superior to trees with inadequate illumination (Mann-Whitney test, $Z = 3,82, p < 0,001$, $N = 164$). In the thinned sub-plots, increments were maintained (Table 2). From 1989, the increment differences between control and treatment were highly significant (Table 2).

Table 2. Comparison of diameter increments of Laetia procera in a secondary rain forest of 15 years of age at the beginning of the study, in relation to a thinning carried out in the first semester of 1989

Period	Median Increment (cm/yr) Control	Thin	Mann-Whitney Z	P
1987-88	0,4	0,4	0,74	N.S.
1988-89	0,3	0,4	1,58	N.S.
1989-90	0,2	0,45	3,80	**
1990-91	0,1	0,3	3,29	**
1991-92	0,1	0,3	3,55	**

The preliminary conclusions and recommendations of the research in secondary rain forests are: 1. The growth patterns of the commercial mass in secondary rain forests are much more simple than in exploited primary rain forests. Initial size is in many cases an excellent indicator of the vigor of a tree and the growth of the dominant and co-dominant trees is rapid and with a low variation. Therefore, simple silvicultural ideas derived from the ones for plantations are applicable to long-lived intolerants in secondary rain forests, and simple models of growth and yield based on average increments can be experimented. 2. Nevertheless, there are important variations in behavior among species and, currently, there is not enough detailed information to group them in accordance with growth and yield patterns; besides, it is not known the site effect on secondary rain forests. 3. Research institutions must back up the secondary rain forest management initiatives with growth and yield studies in forests in all subsequent phases, in different sites and under different treatments.

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DEVELOPMENT OF FOREST MANAGEMENT TECHNIQUES FOR TROPICAL HIGH MOUNTAIN PRIMARY OAK-BAMBOO FOREST OF THE CORDILLERA DE TALAMANCA, COSTA RICA

Robin aus der Beek

RESUMEN: Se resúmen los resultados de una investigación en proceso sobre la silvicultura y el manejo de un bosque mortano primario de roble-bambú. Se demuestra la importancia de respetar ciertos principios para lograr reducir daños sobre el bosque y cambiar la producción de madera con la conservación de los ecosistemas.

The wood demand on one hand, and the deforestation produced by it on the other, put the forestry sector of Costa Rica in a worrying situation of conflict. Therefore, besides measures like the establishment of total protection zones, it is essential that production forest is of area big enough to absorb, in a permanent and sustainable way, the demand for timber and other forest products (firewood, poles, charcoal, etc.). However, it is necessary to apply a management based on principles that can guarantee a harmonization of forest conservation and exploitation. This will lead to fundamental changes in the present traditional concept of forest exploitation.

Since 1984, the Tropical Agronomic Research and Training Center (CATIE), in collaboration with the Swiss Development Cooperation Agency (COSUDE), has carried out a research project in Natural Forest Silviculture (SBN Project), with the purpose of contributing to the development and adoption of forest management systems that are ecologically sustainable, technically feasible, economically attractive and socially equitable.

Even though the term "sustainable forest management" is used very frequently among forestry professionals, it does not always have a clear and unanimous definition, nor ar its implications always known or appreciated. Therefore, it is appropriate to give a definition of the concept of sustainability adopted for the proposed forest management:

"Forest management is considered sustainable if it assures for the present and future generations wood production, with intrinsic benefits and other goods in a perpetual (without interruptions) and optimum (better relation between costs and benefits) way."(1)

From this definition, importance of a correct evaluation of the different demands to the forest and the planning of the forest management is evident. It should be mentioned that the production of wood is not at first sight irreconcilable with the need to protect a hydrographic basin, with the maintenance of soil fertility, or with the demand for recreational areas, provided the three basic principles for forest management are respected:

I. Silviculture based on natural processes

"The conservation of a productive forest ecosystem requires silvicultural interventions to maintain or stimulate the natural productive processes of the ecosystem."

II. Medium and long-term forest order

"The conservation of a productive forest ecosystem requires a medium and long-term forest planning: the forest order".

III. Careful extraction:

"The conservation of a productive forest ecosystem is possible only if careful extraction techniques are applied, to reduce to a minimum damage the forest, the natural regeneration and the soil".

Applying these principles to the high mountain primary oak-bamboo forest of the Cordillera de Talamanca, the SBN Project demonstrated, in a preliminary form, that harvest production and ecosystem conservation can be reconciled. Some of the results obtained in the first silvicultural interventions are presented below:

Ecological aspects:

Due to the need for sound knowledge of the ecological conditions of the ecosystem, the SBN Project collected important information on the composition, structure and dynamics of these forests. A very high flower homogeneity, fair high basal area (42,6-51,8 m^2) and volume of commercial wood (508-643 m^3) (d > = 30 cm) were found. The natural regeneration of tree species is very high (7500 plants Ha^{-1} with height > = 50 < = 250 cm) and dominated by commercial species (2). On the other hand, the annual diametric growth per individual tree is very low and it varies between 1-3 mm/year. Nevertheless, due to a great quantity of individuals per hectare, the annual growth of wood volume is estimated as 3-5m^3/ha^{-1}.

Forest functions:

Contrary to a private forest farm where, in the majority of the cases, forest management is aimed wholly at short-term profit, in the case of the high mountain primary oak-bamboo forest in the Cordillera de Talamanca, the interests of society as a whole should be considered. This implies a detailed evaluation of these interests and, consequently, the search for compromises where conflictive situations arise.

The main functions of the high mountain primary oak-bamboo forest are presented below:

Main functions:

-Protection (erosion, landslides)
-Maintenance of a hydric regime
-Conservation of the faunal and floral biodiversity

Other functions:
-Wood production, firewood, poles and charcoal
-Recreation and tourism
-Employment production

Silvicultural Criteria applied:

Silvicultural interventions were made based on the specific ecological characteristics of the high mountain primary oak-bamboo forest, using the following criteria of intervention:
-Good quality trees are favored and are not cut
-Low quality trees, whose fall could cause damage, are cut

-Small trees are cut, if they are competing with better quality trees
-Small groups of regeneration are favored by cutting the big trees that take off the light
-Dead stems are left to facilitate nesting of quetzals and other birds
-Ecologically important species are favored, even if they are of low quality

Careful forest removal:

As it was previously mentioned, a careful extraction is one of the basic characteristics of the sustainable forest management. This implied the construction of an adequate road network (forestry road, and skidding rails); training and supervision of working personnel in direct felling; integral exploitation of the felled trees (producing firewood, poles and charcoal with the forest residue); detailed organization of field work. More details on this are presented in another report of this event (see D. Quirós, H. Tanner, G. Venegas).

Economic aspects:

Besides the ecological sustainability and the technical feasibility, another basic aspect to consider is the forest management to a natural forest is its economic profitability. Considering the costs and benefits of the silvicultural interventions made, the obtained profit margins are very promising. However, it should be considered that the costs in this type of intervention are not only limited to the extraction work, but that expenditures, strictly related to the carrying out of a management plan, should also be considered, like planning, organization, maintenance, administration, etc.,. With this purpose, a detailed economic analysis was made to propose a self-sufficient forest company, capable of managing in a sustainable and profitable way a determined area of high mountain primary oak-bamboo forest of the Cordillera de Talamanca. The results obtained are presented in another report of the Scientific Week of CATIE (see R. aus der Beek, "Description of a farm forest company for the high mountain primary oak-bamboo forest of the Talamanca Cordillera, Costa Rica").

The results obtained by the Natural Forest Silvicuture Project (CATIE/COSUDE) demonstrate, although in a preliminary way, that the proposed forest management besides being ecologically sustainable and technically feasible, also guarantees economic profit from the exploitation. The farm forest company besides obtaining good profit margins, will allow the farmers to see the forest as a source of work and income and not as an obstacle to carrying out other activities; recognizing, therefore, the usefulness of its conservation.

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YIELDS AND COSTS OF THE INITIAL MANAGEMENT OPERATIONS IN A PRIMARY RAIN FOREST IN THE ATLANTIC ZONE OF COSTA RICA

Fernando Carrera

RESUMEN: Esta investigación detalla los rendimientos y costos en que incurrieron cada una de las actividades iniciales que se llevaron a cabo para implementar un régimen de manejo forestal en un bosque primario de 30 ha. en una finca particular en la Zona Atlántica de Costa Rica. Los impactos de las operaciones forestales también fueron evaluados en términos del daño causado a la vegetación remanente y al grado de daños al suelo.

It is evident that the best and most efficient tool for the conservation of the tropical forests is through its sustainable management. However, despite the fact that the technical aspects of silviculture and forest management are more than a century old, it is amazing to note the lack of economic information available, to assist in the planning and to quantify the productive process at the farm level. This is one of the most severe limitations for its effective implementation.

The objective of this research is to contribute to provide part of this information, through the determination of the yields obtained and costs incurred during the execution of the first phase of a forest management plan incorporating improved harvesting techniques on 30 ha of primary forest on the farm "Los Laureles de Corinto", in Guápiles, Costa Rica, which is at 290 m. above sea level, receives 4143 mm rainfall per year, and has a mean annual temperature of 23.7°C. Ecologically, it forms part of the very wet tropical forest life zone (Holdridge). This research was carried out with the technical and financial support of the project RENARM/Production in Natural Forests Project and the Foundation for the Development of the Central Volcanic Cordillera (FUNDECOR).

The plan considered the implementation of a technically-planned forest harvesting operation, while attempting to minimize the damage to the forest, without loss of efficiency levels. The basis for the planning was an operational inventory and the central objective was to obtain information on the physical location of the trees to be removed and the characteristics of the landscape. As a product of this activity, a base map was elaborated to allow the selection of the trees destined for extraction and those to be reserved as seedtrees, as well as for determining the outline of skidding trails, in order to avoid unnecessary movement of machinery.

Directional felling was carried out, trying to leave the logs in a good position for their subsequent skidding, and in order to avoid damage to the commercial trees of the future harvest. The skidding was done in two phases, using a Caterpillar D-4D, equipped with a winch and 50 m of cable. During the first phase, the logs were skidded from the stump to the forest landing. In the second phase they were skidded from the forest landing to a roadside loading.

Unlike the traditional skidding, where the tractor goes right to the stump to make the skid, in this case the cable was pulled out to the stump and the log winched to the tractor stationed on the skid trails thereby, reducing considerably the presence of the tractor in the forest and hence disturbances to the soil and vegetation. The loading of logs onto the trucks was done with the tractor because it was impossible to obtain a front-end loader. After the harvesting it was neces-

sary to repair the access road and the main skid-trails in order to leave them in good conditions for future use.

When the harvesting operation ended, a "diagnostic sampling" was made to determine the need for applying a silvicultural treatment. The results indicated that 99% of the area was adequately occupied by individual trees catalogued as outstanding future harvest trees, and this was largely a consequence of the care taken during the controlled harvesting.

The yields and costs structure is presented in Table 1. It is necessary to clarify that the results obtained are specific for this area, nevertheless, they provide a good reference guide due to the lack of information of this kind. It can be noticed that the pre-harvest activities represented only a small part of the total cost of the operations (8.3%). However, its contribution in practical terms, was basic to achieving the objectives of the improved harvesting operations. The yields and costs of the directional felling activity were similar to the ones reported by the traditional felling in Costa Rica. Nevertheless, its use resulted in minimizing damage to acceptable levels and in facilitating the implementation and efficiency of the skidding operation.

The damage to the residual vegetation was just 12.9% of the initial basal area, whereas the area subject to significant soil disturbance was less than 5%.

It is recommended that the research be repeated in other farms, in order to obtain conclusive results under different social and physical conditions, with the purpose of helping to promote the management of forests with productive potential, as a real alternative for their conservation.

TABLE 1. Yields and costs of the initial management operations in 30 ha of primary forest in the farm "Los Laureles de Corinto", in Guápiles, Costa Rica.

OPERATION	Daily Yield	Total Cost (US$)	Percentage (%)
PRE-HARVESTING			
Inventory			
Tracking	1.200 m.	338,7	3,5
Census	4,3 Ha.	241,9	2,5
Demarkation of trees	85 trees	59,1	0,6
Location of trails			
Location	750 m.	114,0	1,2
Extension	500 m.	51,2	0,5
Sub-Total		804,9	8,3
HARVESTING			
Directional felling	48 m^3	606,2	6,2
Controlled skidding			
1st phase	32,4 m^3	3.071,5	31,5
2nd phase	36,7 m^3	2.711,8	27,8
Loading	20,0 m^3	1.564,7	16,0
Control		598,8	6,1
Sub-Total		8,553,0	87,7
POST-HARVESTING			
Road repair	1.280 m.	301,1	3,1
Diagnostic Sampling	99 plot	95,5	1,0
Sub-Total		396,6	4,1
TOTAL		9.754,5	100,0

SUSTAINABLE MANAGEMENT OF NATURAL FOREST ON A CATTLE FARM: A CASE STUDY IN SAN RAFAEL DE BORDON, BAJA TALAMANCA

Diomedes Londoño Maturana
Tannia Ammour

RESUMEN: Este estudio pretende diseñar un modelo de manejo sostenible del bosque natural remante en una finca situada en el área de Talamanca (Costa Rica), por medio de metodología participativa con el propósito de integrar a la familia en los procesos de investigación y de decisión técnica. Un análisis financiero comparativo del manejo del bosque remanente de una finca ganadera y un análisis financiero de toda la finca fueron elaborados en base a dos escenarios: i) el actual manejo tradicional de la finca y ii) la incorporación de manejo sostenible del bosque remanente de la finca.

La evaluación financiera del sistema de manejo de bosque muestra que las actividades forestales permiten un mayor ingreso a la familia que las actividades pecuarias. Sin embargo, la actividad forestal presentó um menor ingreso en relación a la tierra cuando se compara al manejo tradicional de la ganadería.

Los resultados de este estudio también indican que el manejo sostenible del bosque natural es económicamente competitivo dentro de las actividades productivas de la finca y que puede generar ingreso a la familia, al mismo tiempo que promueve la conservación del bosque. La decisión de incorporar el manejo forestal como una actividad productiva es la decisión correcta.

The expansion of the agricultural frontier in forest lands is currently a common process in the tropics that threatens to exhaust the existing reserves of the wet tropical forest; this is the case of the community of San Rafael de Bordón in Baja Talamanca, Costa Rica, where the predominant productive activity is the cattle raising at the expense of the forest.

This research was developed within the framework of the Conservation for Central America's Sustainable Development Project. The objective was to define a model for a sustainable management of remaining natural forest in a cattle raising farm, as a competitive production option within the economic activities of the system. It also tries to develop a participatory methodology that takes into account the farmer and his family's expectations and assures his effective participation in planning and decision making on the model and its implementation.

The work took place in Costa Rica, in a farm located in San Rafael de Bordón, district of Cahuita, Baja Talamanca canton, in the province of Limón, at 200 m over the sea level, 3000 mm rainfall and an average temperature of 26° C; ecologically it corresponds to the wet tropical forest, transition to the very wet tropical forest (Holdridge).

The information for the elaboration of the management plan was obtained through an unrestricted systematic sampling, applied with different intensities of sampling, according to the type of forest (10% of the area in primary forest, 18.4 in secondary forest sector I, and 14.5% in sector II). The vegetation inventory included trees starting from 10 cm of diameter at breast-height (DBH) and the non-wood forest products of interest, selected in basis to previous experiences of the Olafo project.

The main structural characteristics of the forest were determined from the obtained data, such as abundance, frequency and dominance, basal area, and average volumes for each type of forest and for species classified in commercial groups (Hutchinson, 1987 and Finnegan and Sabogal, 1988), and in ecological groups (Finnegan and Sabogal, 1988). The elaboration of the management plan was based on this information.

The financial analysis of the farm pretended to evaluate the contribution of a new productive component to the farm system. First, it proposed to compare the results of the forest management and the other productive sub-systems; and in a second step, the global result of the farm was projected in two scenarios for 20 years, the scope of the forest management planning.

The first scenario is the traditional current management of the farm: 1) growing stock is sold and 2) the degradated area turns into pasture to maintain and/or increase the quantity of animals. In the second scenario, the farm incorporates the forest management as a permanent productive activity and stabilizes the breeding stock, having as the limit the current number of animals.

The financial indicators used to measure the annual results of each sub-system and of the whole farm in the two proposed scenarios are the total gross margin, per worked day and per hectare, the net cash flow, the total net income and total net family income, per worked day and per hectare, for the projected period.

The proposed management plan for the farm's natural forests, based in a polycycle silvicultural system with annual low intensity interventions, consists of a felling cycle of 20 years, where the minimum felling diameter (MFD) is 60 cm of DBH for all the species, with the exception of Cordia alliodora and Guarena sp, for which 50 cm was established. The annual felling volumes oscillate between 50 and 55 m^3/Ha/year; based in an IMA of 2.75 m^3/Ha/year of commercial volume for the whole forest.

The results of financial analysis for each productive activities are: the annual average of the gross margin per day worked day obtained for the forest management, is considerably higher than for the cattle, in any of the two considered scenarios. However, when the annual/Ha average gross margin of the sub-system is analyzed, it is slightly higher in relation to cattle production activity sub-system in scenario I ($101.80 against $93.63), but slightly lower compared with the result of the cattle raising sub-system in scenario II ($101.80 against $104.95). That means that the forest activity pays more than a family wage (opportunity cost of labor force in the area), while there is no significative difference related to land retribution.

This is confirmed by the values obtained for the net family income that reaches $5,271.79 for the forest sub-system and $12,435.74 for the cattle raising sub-system in scenario I and II respectively. However, the average annual values of daily net family income are higher in the forest sub-system compared with the two results for the cattle raising sub-system ($21.37 vs. $14.52 and $13.20 respectively).

This is due to the fact that the forest work demands less family work (an average of 233 day's wage/year against 923.8 and 684.3 day's wage/year for the cattle raising sub-system in the scenario I and II).

On the other hand, the net family income per hectare for the forest sub-system is only slightly lower than the cattle raising sub-system in the two scenarios considered ($103.06 vs $112.49 and $116.89 respectively).

When compared, the specific results for the cattle raising in the two scenarios, we can conclude that for scenario I, the increase in the use of labor and land does not compensate the productivity of those increases. It is pointed out then, that the daily net family income and per hectare produced (Table 1), in both scenarios, highly surpass the opportunity costs labor and of the land in pastures, in the region ($3.93 and $45.25 respectively) and even, the official minimum wage $5.28/day. From the farmer's point of view, this activity turns into an attractive alternative.

Looked in its global context, scenario II, is the best economic alternative for the farm; the forest under management makes its own productive potential, establishing a situation that besides giving a more rational use to the land, is financially profitable, that highly improves the family economy.

Table 1.Comparative Results of the Farm in Scenario I vs. Scenario II

Financial Indicators*	Scenario I	Scenario II
Net Family Income	2091.7	2527.2
Net Family Income/Day's Wage	2.1	2.6
Net Family Income/Ha.	14.1	17.1

* All the values in thousands of Costa Rican Colones
US$1.00 = ¢159.13

The results indicate that "the forest management with sustainability criteria is an economically competitive activity within the productive activities of a farm", and its incorporation in the productive activity is a correct decision of the family, that improves the farm economy and guarantees the forest conservation.

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Genetics Improvement

EVALUATION OF PROVENANCES OF FIVE POTENTIAL SPECIES FOR EL SALVADOR

Rodolfo Salazar

RESUMEN. Se presentan los resultados de crecimiento de varias procedencias de E. camaldulensis, E. terenticornis, E. grandis, E. saligna y A. mangium despues de 2.5 a 4.5 años de crecimiento en un ensayo de seis bloques al azar, en El Salvador.

Since 1980, CATIE in a joint effort with the national institutions responsible for forest activities in El Salvador, began a selection process of multiple-use tree species, to meet the demand by forest producers in an increasing population. During the first phase, more than 10 different species were selected for different site conditions and different market needs. Later, a second phase was conducted to identify the best germplasm sources of those species. This document summarizes the preliminary results of six provenance trials from five of the species selected.

Experiments were established in July and August 1986, using a completely randomized block design, with four repetitions and 25 tree useful plots; except the E. camaldulensis and A. mangium trials which were established in July 1988, with three repetitions and a 16 tree useful plot. Table 1 shows source sites characteristics of the provenances used for these tests.

In La Carrera, Usulután at 75 masl, 1756 mm rainfall and 26.6^{o}C temperature, the 10 E. camaldulensis provenances showed a survival rate ranging between 71 and 94% at 4.5 years. The provenance from Leon, Nicaragua reached 12.0 cm dap as the highest growth rate (X-10.7 cm), while provenance from Wrotham Park showed highest total height of 15.7 m(X-13.5m. Provenance from Creek showed the lowest growth values and Petford provenance surpassed the average.

In the second trial of E. camaldulensis established in Armenia, Sonsonate at 470 masl, 1672 mm rainfall and 23.8^{o}C temperature, provenance from Petford showed 9,8 cm dap (X-9.4cm) and 13.6m total height (X-12.4m) at 2.5 years, followed by the provenance from Leon, Nicaragua. Survival was higher than 94%.

Table 1. Summary of six provenances of five species in El Salvador

PROVENANCE		CODE*	LATITUDE	LONGITUDE	ELEVATION (masl)	TEMP. (°C)	RAINFALL (mm)
			Eucalyptus camaldulensis				
Leon,Nicaragua		1565	12°30'S	87°00'E	100	27.9	1159
Emu Creek,Petford	QLD.	1826	17°20'S	144°58'E	460	22.8	694
Wrotham Park	QLD.	1827	16°48'S	144°10'E	230	25.5	876
Gilbert River	QLD.	1828	8°18'S	142°53'E	150	26.0	726
Gibb Kimberley	WA.	1829	16°08'S	126°30'E	430	25.3	844
Victoria River	NT.	1830	15°35'S	131°02'E	35	27.3	756
Cockatoo Creek	NT.	1831	15°38'S	129°01'E	50	28.2	822
E of Tennant CK	NT.	1832	19°47'S	134°30'E	300	25.7	366
Ord River	WA.	1833	17°28'S	127°58'E	280	26.8	558
N.Fit.Crossing	WA.	1834	18°06'S	125°42'E	110	28.0	493
			Eucalyptus camaldulensis				
León Nicaragua		1565	12°30'S	87°00'E	100	27.9	1159
Inglewood	QLD.	4014	28°25'S	151°05'E	280	18.6	602
W. Dimbulam	QLD.	4012	17°10'S	144°56'E	420	23.1	725
Gibb. Kinberley	WA.	1829	16°08'S	126°30'E	430	25.3	844
Petford	QLD.	4010	17°17'S	145°59'E	590	21.8	673
DPRI		4013					
			Eucalyptus tereticornis				
Helenvale	QLD.	1835	15°46'S	145°14'E	120		
Marreba	QLD.	1836	16°46'S	145°15'E	380		
Crediton	QLD.	1837	21°00'S	148°30'E	700		
Kennedy River	QLD.	1838	15°26'S	144°11'E	60		
Palmer R. D.	QLD.	1839	16°07'S	144°47'E	365		
			Eucalyptus grandis				
Paluma	QLD.	1840	19°00'S	146°00'E	900		
Heberton	QLD.	1841	17°21'S	145°27'E	1000		
Lewis-ST.Frazer	QLD.	1842	16°37'S	145°16'E	900		
Harbour	NSW.	1843	30°22'S	152°56'E	100		
			Eucalyptus saligna				
Consuelo	QLD.	1844	24°57'S	148°03'E	1090		
14 K W of Bulahdela	NSW.	1845	32°24'S	152°06'E	53		
W os Coffs Harbour	NSW.	1846	30°22'S	152°56'E	100		
E of Guyra	NSW.	1847	30°06'S	152°08'E	1100		
			Acacia mangium				
Oriono, River	PNG.	2741	08°50'S	143°08'E	30	26.2	2084
S. of Helenvale	QLD.	2742					
Lanner Cost,s	QLD.	2744	18°37'S	145°54'E	70	24.1	1492
66K N Townsville	QLD.	2745	18°57'S	146°17'E	20	24.0	678

* CATIE Latin American Tree Seed Bank Registers

In the E. tereticornis trial established at Hda. La Carrera, Usulután at 75 masl, 2017 mm rainfall and 26.6°C temperature, all five provenances showed 78 to 88% survival at 4.5 years; Helenvale and Crediton reached 12.7 dm dap as the highest (X-11.9cm) with 14.7 and 14.2 m height respectively (X-13.7m); Kenedy River showed the lowest values, that is, 12.5 dap and 11.6m height.

From the four provenances of E. grandis planted at Hda. Copapayo, Armenia, Sonsonate at 470 masl, 1672 mm rainfall and 23.8°C, at 4.5 years, survival rate ranged between 54 and 60%. Heberton showed the highest value. Average dap was 8.5cm, reaching 9.0 cm for Harbor. Average total height was 11.0 m. All four sources showed similar values.

From the four provenances of E. saligna planted in Hda. Copapayo, Sonsonate at 470 masl, 1672mm rainfall and 23.8°C temperature, at 3.7 years, Consuelo, Bulahdelah and Coffs Harbor provenances showed dap values slightly higher than the 8.7cm average. The four provenances showed heights very similar to the 10.0m average. Survival was relatively low for the four seed sources and ranged between 43 and 55%.

In Hda. Sta Teresa, Sonsonate at 470 masl, 1672mm rainfall and 23.8°C temperature, four provenances of Acacia mangium were planted. At 2.5 years, provenance from Oriono reached 9.7 cm dap (X-8.7cm) and 10.4m total height (X-9.3), considered to be the best; Helenvale provenance reached 7.9 cm dap and 8.3m height as the lowest value. Survival was higher by 83%. In general four sources showed a very similar behavior.

Significant differences between provenances of the species tested were observed in the trial established in Hda. La Carrera, Sonsonate, using E. camaldulensis. In the other five trials using E. camaldulensis, E. tereticornis, E. grandis, E. saligna and A. mangium differences between provenances in terms of dap and total height were minimum.

These results may be used as basic information for forestry activities to define the establishment of seed producing areas and to continue with germplasm evaluation processes at the progene level, to establish seedling seed orchards for potential species in El Salvador.

RESPONDING TO PRACTICE AND AFFECTING POLICY: THE EXPERIENCE OF THE MADELEÑA-3 PROJECT IN CENTRAL AMERICA[1]

Elvira Belaunde, Carlos Rivas

INTRODUCTION

The history of the Madeleña Project—the broadest-based forestry project in the region—illustrates how lessons learned from implementation in particular countries have been fed back into project goals, reorienting objectives and creating a particular project ethos. But even more interesting is the way in which this local national experience has been used to benefit the region as a whole through the Madeleña headquarters in Costa Rica.

The Madeleña project is based at CATIE (Centro Agronómico Tropical de Investigación y de Enseñanza) in Costa Rica and works throughout the Central American region, covering Honduras, Guatemala, El Salvador, Nicaragua, Costa Rica and Panama. In each country the project works in partnership with national forestry institutions.

This paper examines the evolution of Madeleña-3 and how changes within the project have encouraged new thinking and policy in the Central American forestry sector, at all levels. The first section describes the general evolution of the Madeleña-3 project. The second section analyzes the project's history and influence in Costa Rica and El Salvador. Finally, the constraints and challenges facing the project in the future are examined.

THE EVOLUTION OF THE MADELEÑA-3 PROJECT

Outline of Deforestation in Central America

Deforestation is a serious problem throughout Central America.The reasons for this destruction of forest are complex and are subject to local historical and economic variation. The main causes are:

-Models of economic development stressing agricultural exports which has dictated the clearance of large areas of forest for agricultural production.
-A policy of internal colonization of virgin wasted forest land and the population movements which have accompanied implementation of this development policy.
-Population growth.
-Expansion of the area under cultivation to meet food requirements.
-Land redistribution.
-A dependency on fuelwood as a source of energy.
-The deeply engrained extractive character of forest industry, mainly logging, which gives little consideration to the management and renewal of forest resources.
-Inconsistent forest policies which rarely correspond to the true needs and practices of the population. (Rivas, 1992; Utting, 1991).

The shrinking of forest resources has serious environmental and social consequences, especially for the rural poor. On the one hand, deforestation is seen as a device for dealing with poverty by 'exporting' it to forest areas, it takes place to create new farms and sources of income and subsis-

tence. On the other hand, this move brings only temporary relief from poverty, because excessive utilization of land and trees leads to a rapid exhaustion of land resources and productivity.

During the last decade considerable effort has been made to control deforestation. The Madeleña project has made a determinant effort over the last 13 years to counteract the loss of tree resources. The project started in 1981 as the Fuelwood and Alternative Energy Sources or Leña (fuelwood) Project. In 1986, a second phase began; renamed the Multi-purpose Tree Cultivation or Madeleña (timber and fuelwood) Project. The third phase, Madeleña-3 (1991-95) is devoted to a broader extension of multi-purpose tree cultivation.

The Phases of the Madeleña Project

Fuelwood and the farmer: The first phase of the Madeleña project (1981-85) aimed to develop and demonstrate improved silvicultural practices with trees for fuel production and to transfer this technology to forestry institutions and technical staff in the Central American region. The goal was to improve the welfare of low **income rural groups by increasing the supply of low-cost energy.**

Through the contact with farmers, technical staff learnt to identify farmers' production priorities, including their perception of the role of trees within farming systems. It became clear that fuelwood, although a crucial and often scarce resource, was not the only priority of the rural poor.

Focusing on farmers' priorities and building the technical knowledge to help them: Farmers' needs and perceptions of tree growing led to a change of objectives in the **second phase (1986-91)** of the project. Twenty four well-known species were chosen for their multi-purpose potential and faster growth rates and in-depth on-farm research was carried out for these species in close collaboration with farmers. The new research included both silvicultural and socioeconomic studies, crucial for understanding how tree planting could be an economic complement to their production systems.

In this phase, the project trained and influenced the thinking of many foresters who took this knowledge back to their place of work; published silvicultural and socioeconomic research findings and produced training materials aimed at a wide audience. Also the MIRA system (Tree Resource Information Management System) was created, which includes a database with silviculture, socioeconomic and forestry extension components. Finally (in this phase) the project developed a regional strategy for forestry extension. In addition to working in partnership with national forestry agencies, the project established links with 21 forestry institutions, NGOs, private firms and universities, as a first step towards the creation of a network for the dissemination of the information produced by the project.

From more effective extension to better regional dissemination and collaboration: The third phase of the project, Madeleña-3 (1991-95) aims principally at the development of this strategy of dissemination through a strengthening of inter-institutional collaboration. Another objective is the continuation of relevant silvicultural, socioeconomic and extension research.

Building in-country networks with links to CATIE: In each country, the project coordinates its actions with a network of national institutions, NGOs and private firms. Each institution has a representative who liaises with the project and is an active participant in the national network.

Building country-to-country links which bypass CATIE: The project also fosters bilateral collaboration between the institutions belonging to the networks within each country and regional-

ly. To aid this collaboration the project has instituted regular national and regional meetings between network representatives, used to organize activities, plan training courses and events, arrange joint publications and even exchange seed.

Supporting the entire regional network with information and training opportunities: Through this network, the project also formally organizes and carries out a variety of activities in support of its members. It provides training courses, technical assistance, facilitates the production and publication of extension materials suggested by members and helps them monitor their extension activities.

The Interface Between the Project's Regional and National Levels

Madeleña's regional centre is based at CATIE, but in each country, the project's activities are supervised by a basic team composed of a national coordinator hired by the project and a national director hired by the national partner forestry agency. National teams keep in close contact with the project's regional administration based at CATIE, but are also independent decision makers. The flexible relationship between the regional centre and national teams is the key to the success of the project.

Although forestry problems and institutions of Central America share common features, each country has different natural and social characteristics, and in each the project has developed a different background and character. Indeed, the relative independence of national teams from the regional centre has allowed initiatives to be taken at a local or national level that were sometimes beyond project expectations. These initiatives have fed back into the project centre at CATIE and helped to broaden the impact of the project on foresters and forestry institutions in Central America as a whole.

MADELEÑA'S OVERALL IMPACT

Over 12 years the Madeleña project has generated and gathered a huge amount of technical information. For instance, its research on multipurpose species constitutes an invaluable source of information for forestry students, projects and institutions in Central America. Above all, it has generated a unique regional model for information sharing in a particular sector, among a set of small adjacent countries.

Many of its supporters also feel that it has made a key contribution to the transformation of forestry institutions and policies. Madeleña has shown its ability to adapt rapidly both at field and at institutional level. The informal relationship between the regional centre at CATIE and the national teams has been at the core of the dynamism of the project as a whole.

Above all, Madeleña has been more than just a project for many people. It has caught the imagination of many of the technicians, extension workers and farmers who have worked with it, because it has actively encouraged foresters to democratize forestry activities and understand local and institutional processes.

Madeleña has also contributed to the institutional strengthening of CATIE itself, as one of its major and longest-lasting projects. It has been able to offer assistance to some of the other projects based in the countries and has played a major role in shaping the current Master's programmes offered by CATIE. These courses are taken by large numbers of foresters from all over Latin America and other countries as well, especially by medium and high ranking decision makers.

Challenges for the Future

The Madeleña project has set itself several goals for the next three years. One of the main needs is to strengthen forestry socioeconomics and give technical assistance in the management of already established plantations. This has been the weak point of many reforestation projects which have concentrated on nurseries and establishment but have disregarded the growth of trees in the long term.

Firstly, the project must train the trainers in plantation management techniques and teach them how important this is for the future viability of reforestation. Secondly, the project must find ways of enhancing the care of plantations. The first step is to support the development of a market for smaller diameter trees, since the best way of ensuring the better management of forestry products is to make them economically more attractive. Another possibility being considered currently in Costa Rica is the introduction of monetary incentives for the management of plantations. This option has all the usual disadvantages, but it could be used to foster the expansion of a forest industry based on plantation products, as well as natural forest.

Another challenge is to strengthen and further extend the cross-nation collaboration between forestry institutions in the region.

The range of contacts that have been possible through Madeleña have led some to ask where the limit to networking should be. With the technician who trains extensionists in the network institutions? With the extensionists in the field? With the farmers?. Some members of the project consider that the only way to obtain reliable information and effectively assist network institutions is to maintain close contact at field level. Other members, principally at the regional centre, consider that the project should work with trainers and leave the execution and monitoring of field activities in the hands of the network institutions. Over the next few years the debate will no doubt generate new approaches and ideas, as previous debates have done, to such good effect, in the past.

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VEGETATIVE PROPAGATION OF TROPICAL TREES: RESULTS AND PRACTICAL IMPLICATIONS

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RESUMEN: El enraizamiento exitoso de estacas de un gran número de especies de árboles tropicales por medio de propagadores de sub-irrigación en el Centro Agronómico Tropical de Investigación y Enseñanza (CATIE), Costa Rica y en el Instituto de Ecología Terrestre (ITE), Escocia. El estudio se concentró en algunos de los factores que operan tanto antes como después de la colecta de estacas y que influyen críticamente en la condición fisiológica y en la formación de raíces en las estacas. Se discuten también las implicaciones prácticas de este estudio.

The importance of vegetative propagation is currently recognized, both for making possible the obtention of dramatic increases in the productivity and quality of forest plantations, and for offering an effective tool for genetic resources conservation. Some of the traditional problems of the vegetative propagation systems, in particular, the low rate of multiplication, the requirement of sophisticated installations, highly qualified personnel, and/or the need of high investment have been overcome through the development of simple and low cost non-mist propagators (Leakey et al. 1990). To achieve the massive multiplication of a species in particular, it is necessary to understand the factors that critically influence the rooting of the cuttings. Among these factors remark the management of donor plants, the propagation environment and its effect on the physiological condition of the material and the treatments applied to the cuttings.

All these factors were studied in a variable degree of detail for the species Albizia guachapele, Acacia mangium, Bombacopsis quinata, Cedrela odorata, Cordia alliodora, Eucalyptus deglupta, Gmelina arborea and Vochysia guatemalensis, through a joint work between CATIE's Forestry Genetic Improvement Project and the Institute of Terrestrial Ecology (ITE), Scotland. The work took place in the experimental plant nursery of CATIE, Turrialba and in the tropicalized greenhouses of ITE, between 1990 and 1993.

This study used young cuttings of 4-6 cm length with a foliar area reduced of 10-60 cm^2 treated with a 0-1,6% concentration of indole-3-butyric acid (AIB), applied with a microsyringe at the base of the cutting in 10 µl of ethanol. The cuttings were established in the propagators using different rooting substrates, mainly sand, sawdust, gravel, or mixture of them, under different irradiation levels.

To evaluate the gas exchange of the donor plants and the cuttings, an infrared gas analyzer was used (IRGA LCA-3), connected to a Parkinson leaf chamber. The fluorescence of the chlorophyll was measured with an Stressmeter PSM Mark II, Bio Monitor. The environmental conditions inside the propagator were measured during the whole process of propagation, with lectures every 10 s, averaged every 15 min., using a Campbell 21 X micrologger connected to sensors for relative humidity, air temperature, soil temperature and irradiance (for details of the description and use of the described equipment, see Mesén 1993).

All the studied species rooted easily, including some previously considered "difficult to root", demonstrating the advantages of the propagation system used. For many of the species, these studies produce the first reports of successful rooting, with production of plants with a normal ortotropic growth (Leakey et al. 1990; Newton et al. 1992).

The process of adventitious root formation depends on a large number of genetic, physiological, morphological and environmental factors, operating both pre- and post-severance in a complex and interrelated way. Besides, evidence was found suggesting that the optimum treatments during the initial phases of the rooting process could not be the same for subsequent phases. This is in accordance with the concept that there are at least two phases in the process of adventitious root formation, and that the factors that influence the initiation of the roots are not necessarily the same that influence the development of the roots.

The species differed in their response to similar treatments, sometimes in a clearly opposite way, probably as the result of genetic differences associated with the adaptation to contrasting ecological conditions of their natural environment.

This study allowed to a better understanding of the effect of a number of factors, both pre- and post-severance, traditionally recognized as crucial in determining the rooting ability of the cuttings.

There is no doubt that the rooting process is complex, determined by a large quantity of interrelated factors that should be optimized. However, the comprehension of the critical factors has allowed the development of technological packages adapted to each species, and the beginning of applied programs for clonal silviculture.

The vegetative propagation, specially the use of rooted cuttings, will bring large benefits to the forest development, as it is evidenced by the great increase in quality and productivity obtained with the eucalyptus in Brazil and Congo, with Triplochiton scleroxylon in West Africa, with G. arborea in Malaysia, with Acacia mangium in Indonesia and with Pinus radiata in Australia, New Zeland and South Africa. In like manner, through the selection and clonal propagation, it is expected an increase in the use of local species with the consequent social, economical and ecological benefits (Leakey 1987). As Zobel (1992) exposed it, the question is not if vegetative propagation has a future in silviculture, but how and when.

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PROCEDURE TO EVALUATE MANAGEMENT EFFECTIVENESS IN PROTECTED AREAS

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RESUMEN: La necesidad de profesionalizar el manejo, así como los retos cada vez más complejos que enfrentan la áreas protegidas de América Latina, destacan la necesidad de aumentar el monitoreo del manejo. Los pasos seguidos en este estudio incluyen i) revisión de literatura y coordinación institucional, ii) identificación de Escenarios, iii) evaluación de los ámbitos y calificación del manejo (administrativo, político, legal, planificación, conocimientos, programas de manejo, usos actuales, características biogeográficas y amenazas). Este procedimiento es considerado objetivo y puede ser aplicado tanto a áreas individuales como a sistemas de áreas protegidas.

From the decade of the 60 up to the middle of the 80, the establishment of protected areas has followed a rising course. Unfortunately, in Latin America the management in this field did not accompany the increase of the number of the protected areas. The limitation and adverse factors they face are various and well known, but very similar among the different geopolitic regions.

This situation, together with the continuous degradation of the natural resources and the little possibility of extending the areas under protection, shows the need of more efforts to be made to achieve an effective management of the already established protected areas. For this purpose, it is necessary to increase the level of management monitoring, in order to identify the gaps and to give priority to the actions needed by the areas to reach their objectives.

During the last years some attempts have been made to measure the management effectiveness and to outline some basic criteria for it (Deshler, 1982; MacKinnan et al., 1986; UICN, 1993). However, there is no technical procedure to allow the evaluation of management of the protected areas in a systematic way, with results that can be compared and reproduced.

The present research tried to elaborate such evaluation procedure. This procedure was applied in two protected areas of Costa Rica: Guayabo National Monument and Carara Biological Reserve. To design the procedure, an exhaustive study was made to select and to group factors or variables influencing the management of the protected wildlands. In relation to their similarity, the selected variables were grouped in domains: administrative, political, legal, planning, knowledge, management programs, current uses, biogeographical characteristics and threats.

With this information, a form was prepared and national and international experts on planning and protected areas management ratified it. At the same time, for each selected variable an evaluation and qualification criteria was established.

The structure of the procedure or its logical schematization, was carried out through the analysis of the work that, in one way or another, partially evaluated aspects of management and through personal consultations with experts. Field observations were very important for the feedback of this phase.

The procedure has the following phases:

Phase I - Preliminary activities

1st Step: Establishment of a team trained in management; standardization of work criteria; distribution of tasks.
2nd Step: Gathering secondary information on the national system of protected areas and the sites to be analyzed.
3rd Step: Previous contacts with the direction of the areas to promote and to establish the logistic conditions for field work.
4th Step: Verification of field necessities.
5th Step: Gathering primary information on area management. It uses semi-structured interviews, group or individual meetings, field trips, personal observations, and workshops. The main actors are the directors of the system and of the areas, neighbors, local development associations, and other NGOs.

Phase II - Scenario definition

1st Step: Current scenario, representing the area situation at the moment of gathering management information.
2nd Step: Optimum scenario, referred to the best state or conditions the area must have to develop its activities and be near to or reach its objectives. It is constructed based on planning documents, which are confronted and complemented by valid primary information, given by the actors that have knowledge of the study site. The optimum scenario must represent the best state for the variables, so that the management can be evaluated.

Phase III - Evaluation of the domains and qualification of the management

Each domain forms a matrix, where the variables are evaluated starting from the comparison of its optimum scenario with the current situation of the area, the specific criteria established for the evaluation and a scale of generalized deliberation.

The appraisal scale allows to obtain real values (reached total) reflecting the current situation, and optimum values (optimum total) for each domain. The sum of each one of these totals, when compared among themselves, produces a value in percentage that, in accordance with an adopted scale, allows to grade the management.

The already mentioned scale has five levels: a) unsatisfactory management ($\leq$ 35%); b) less satisfactory management (36-50%); c) fairly satisfactory management (51-75%); d) satisfactory management (76-89%); e) very satisfactory management ($\geq$ 90%).

The evaluation of the two protected areas, as a test for the procedure, allows to conclude that Guayabo National Monument is been fairly satisfactory managed (58% of the optimum), while the management of Carara Biologic Reserve is less satisfactory (45% of the optimum).

The conclusions:

1. Besides grading the management effectiveness, the procedure developed allows to analyze any number of protected areas, regardless of their management category, making possible to know the causes of the grade, as well as to determine the differences.

2. The construction of the optimum scenario, compared with current conditions, allows to objectively grade the variables.

3. The application of strict and specific criteria to evaluate the variables gives a rigorous grading, reducing possible personal slant.

4. The evaluation results are very useful for planning, because they identify the strengths and weaknesses of the protected areas. They also demonstrate the application levels of specific policies on these areas.

5. Even though it is considered as a progress for Latin America, the procedure needs to be used many times for a better verification of the grade obtained, and also to confirm it as an effective tool for monitoring management of protected areas.

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SEDIMENTATION IMPACT IN HYDROELECTRIC PRODUCTION OF THE CERRON GRANDE RESERVOIR IN EL SALVADOR

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RESUMEN: El proceso de deforestación ha acelerado la erosión en El Salvador. Como consecuencia, los embalses han perdido gradualmente su capacidad de almacenamiento a una tasa inesperadamente alta. En este estudio se parte del balance hídrico para calcular la energía firme del embalse y su reducción debido a la sedimentación. Los resultados preliminares indican que las pérdidas son importante y que para contrarrestar esta tendencia deben implementarse planes de rehabilitación de cuencas.

In Central America, El Salvador is the country most severely affected by deforestation. As an unavoidable consequence of deforestation, the erosion processes have drastically increased. On the other hand, the hydroelectric production depends almost exclusively on the Lempa river, in which four important hydroelectric projects have been constructed, and where more are to be constructed (1). However, the sedimentation process has decreased the storage capacity of the reservoirs with at a rate that surpasses the initial forecasts.

The reservoir of Cerrón Grande is the largest in El Salvador, with a maximum storage volume of 2180 million cubic meters, and is the main control reservoir of the country. It is estimated that the sedimentation produces a reduction of 36 million cubic meters per year (3). The solution to this problem is to continue to construct new projects, at a higher cost and with shorter useful life; or to reduce the sedimentation rate through a vast watershed management program.

The objective of this research is to evaluate the negative impact of sedimentation in the hydroelectric production, in order to facilitate political and financial support to watershed management projects and to attack the causes and not the effects of this serious problem.

The methodology consists of obtaining the hydrologic budget of the reservoir and requires as initial information: the curve of elevation against volume and area, historical data on in-flows, rainfall, evaporation and demand factors. The hydrologic budget is based in the equation (2):

$$S_t = S_{t-1} + I_t - Yd_t - A_t e_t - Q_t \qquad t = 1,2,...,T$$

Where:

S_{t-1}, S_t = Volume at the beginning and at the end of the month t

I_t = In-flow of month t

Y = Firm flow

d_t = Demand factor of month t

A_t = Area of the reservoir mirror in the month t

e_t = Evaporation-rainfall in the month t

Q_t = Volume spilled in month t

The model used was modified to calculate two basic additional aspects:
- Production of firm energy
- Consideration of the curves of elevation-volume and area volume as dynamic elements in the hydrologic budget.

A Table with some of the results for a typical month is presented as follows:

HYDROLOGIC BUDGET OF THE CERRON GRANDE RESERVOIR

Without Sedimentation

MONTH	Q INFLOW M^3*10^6	Q TURBINATED M^3*10^6	EVAP-RAINFALL M^3*10^6	Q-SPILLED M^3*10^6	ENERGY GWH
JANUARY	99	244	17	0	35
FEBRUARY	67	226	17	0	32
MARCH	70	231	19	0	31
APRIL	99	215	14	0	28
MAY	177	205	1	0	26
JUNE	758	164	-11	0	22
JULY	320	223	5	0	32
AUGUST	271	208	9	0	31
SEPTEMBER	991	184	-8	707	28
OCTOBER	600	215	5	379	32
NOVEMBER	191	226	13	0	34
DECEMBER	134	257	16	0	38

With Annual Sedimentation of 36,6 M^3*10^6

MONTH	Q INFLOW M^3*10^6	Q TURBINATED M^3*10^6	EVAP-RAINFAL M^3*10^6	Q-SPILLED M^3*10^6	ENERGY GWH
JANUARY	99	225	16	0	32
FEBRUARY	67	208	16	0	29
MARCH	70	213	19	0	29
APRIL	99	198	14	0	26
MAY	177	189	1	0	24
JUNE	758	150	-11	0	21
JULY	320	205	5	28	31
AUGUST	271	191	9	74	29
SEPTEMBER	991	170	-8	833	26
OCTOBER	600	198	5	400	30
NOVEMBER	191	208	12	0	31
DECEMBER	134	236	15	0	35

Based in the hydrologic budget, the firm energy of the reservoir, which is the annual average energy that can be produced is calculated, so that the minimum level of the reservoir can be reached only once during the analysis period. That is, the energy that can be guaranteed with a high degree of accuracy. The firm energy is initially calculated in the traditional way, with a curve of elevation volume-constant. Next it is calculated with a curve of elevation decreasing volume, due to sedimentation. The reductions of volume and area of the reservoir are calculated monthly in accordance with an exponential equation in function of time. The estimation of the annual sedimentation was based in partial batimetric measures, and in the curve of design suggested by the United States Bureau of Reclamation (USBR), for dams of a similar size as Cerrón Grande reservoir.

As a conclusion, it can be said that the sedimentation produces a reduction in the turbine flow, an increase of the spill flow and most importantly, the firm energy is appreciably reduced. For an analysis period of 10 years there is a 7% reduction, which implies a loss of 2.52×10^6 KWH/year, which in financial terms is a loss of $1,7 million/year. It should be clear that these are preliminary results, and that the process to obtain a more precise estimation continues. These values are based in a relatively short period of analysis in comparison with the useful life of the reservoir. In addition, the loss of the control capacity of Cerrón Grande reservoir produces a reduction in the productivity of the downstream plants.

Finally, it should be mentioned that this model can also be applied to reservoirs with different purposes like irrigation or water supply.

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